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INDIAN JOURNAL OF POWER & RIVER VALLEY DEVELOPMENT

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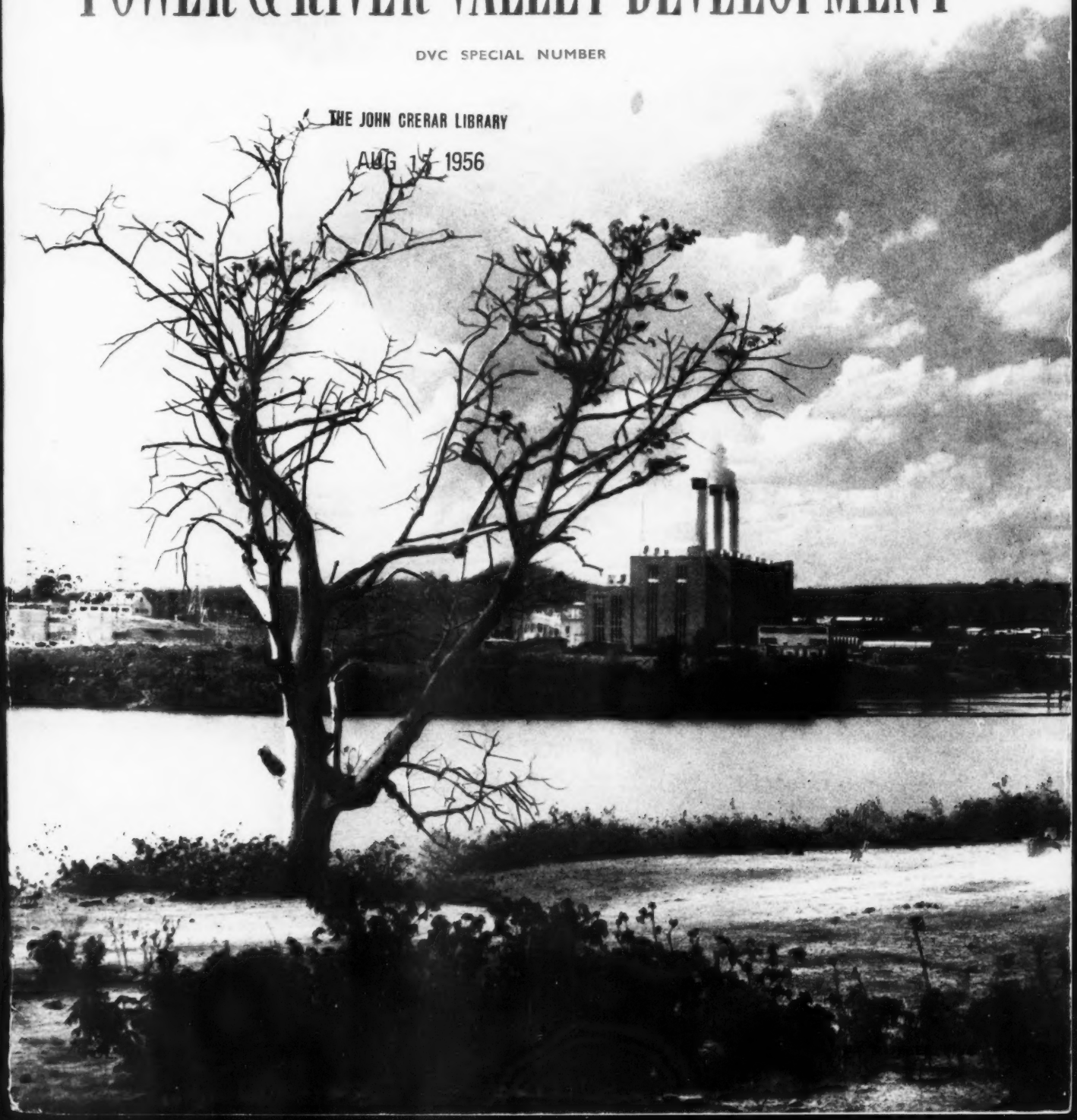

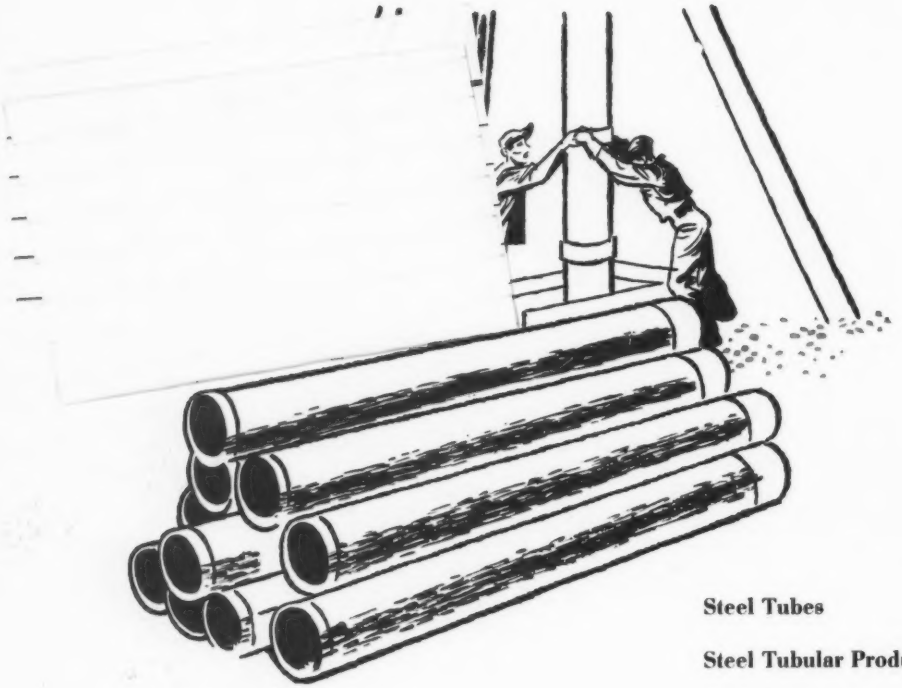

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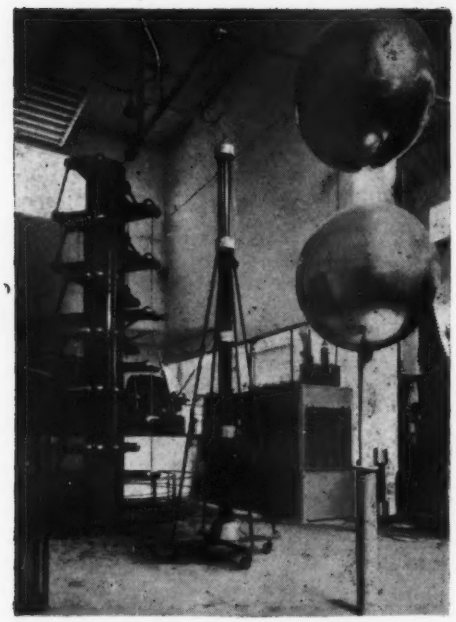

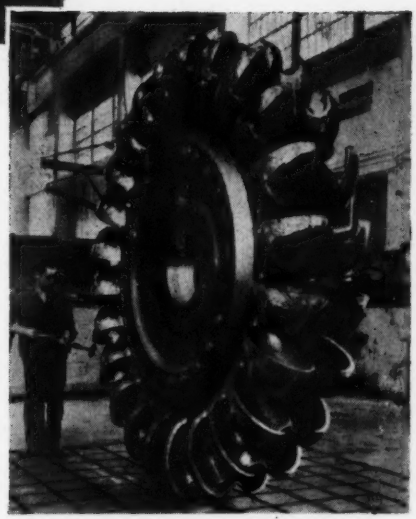

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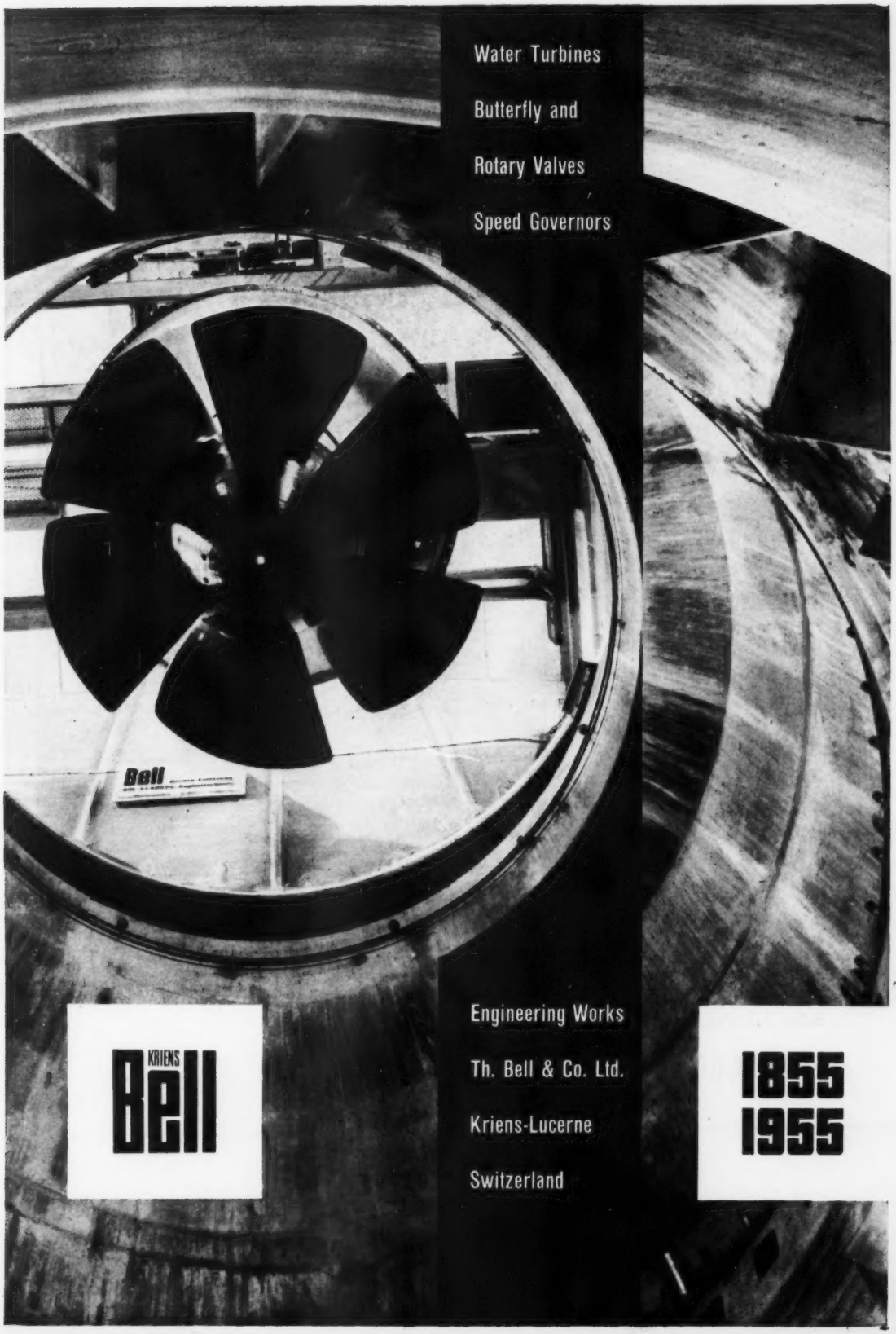
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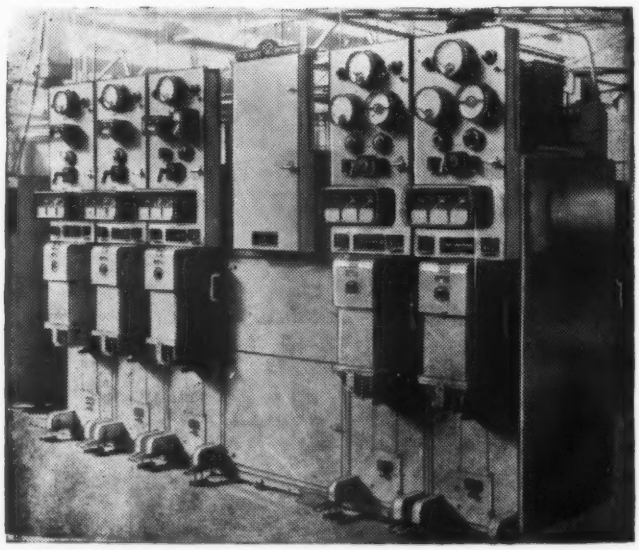

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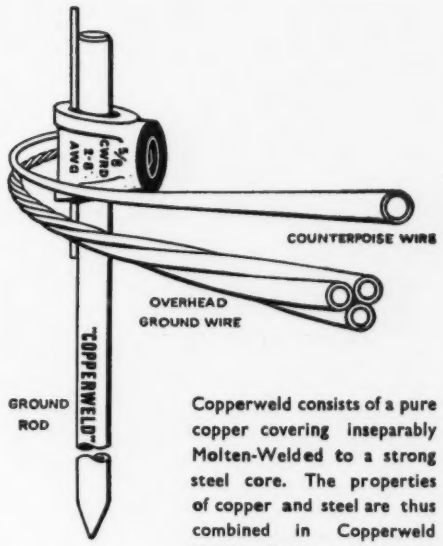

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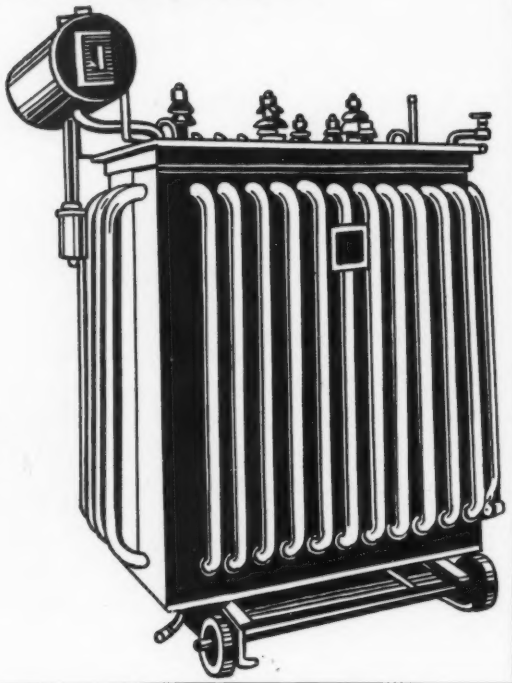

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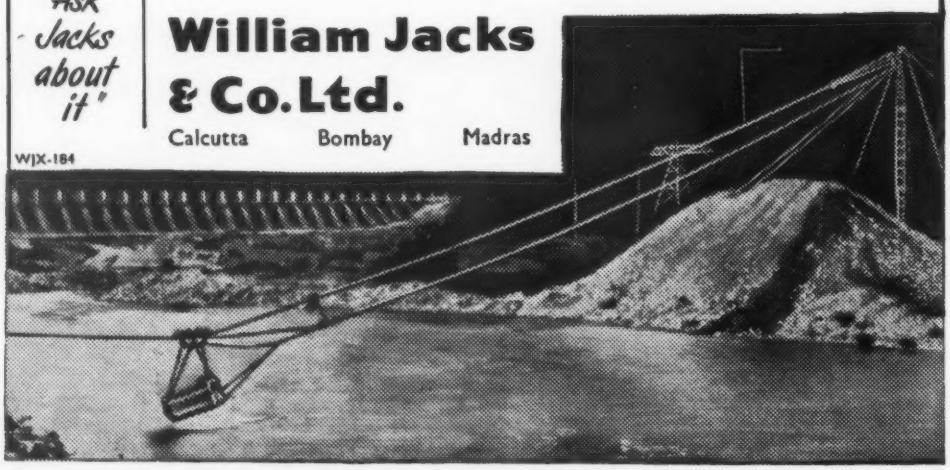

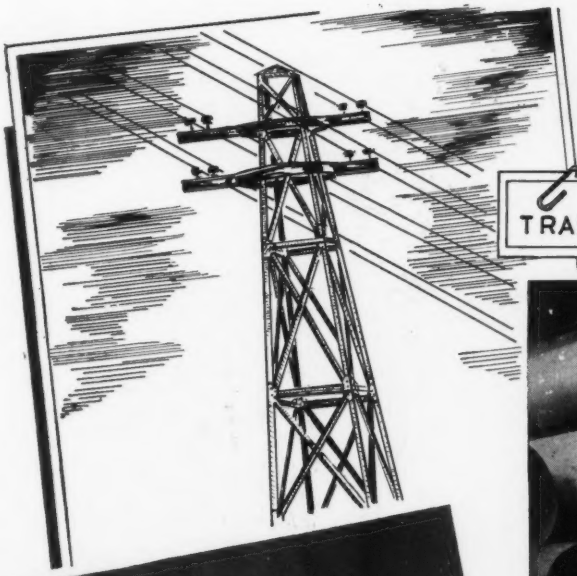

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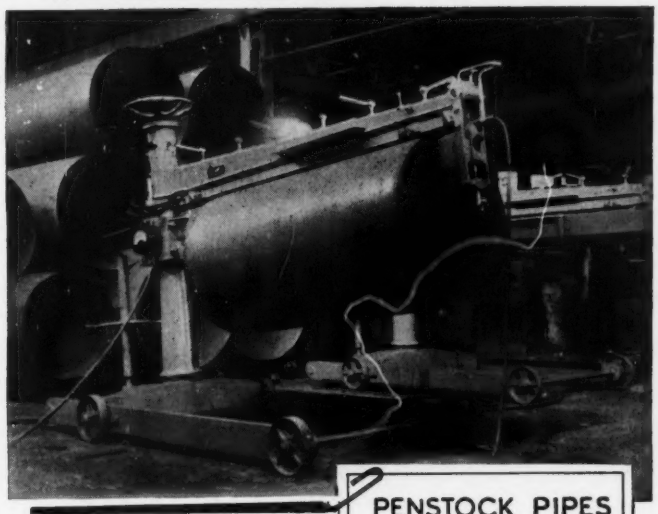

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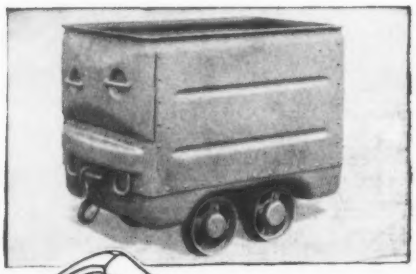
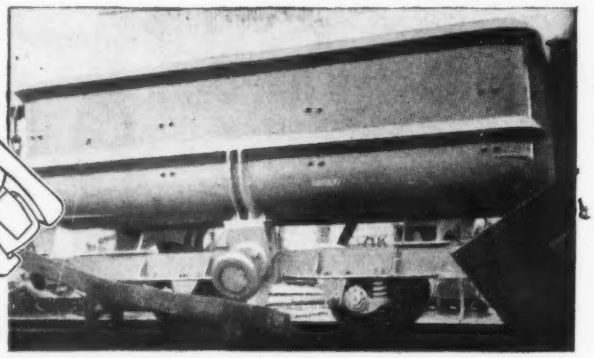
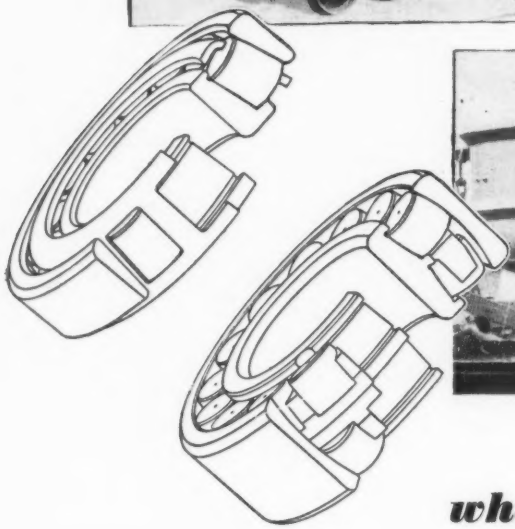


Mine truck with
SKF taper roller bearings

Mine truck with
SKF spherical roller bearings





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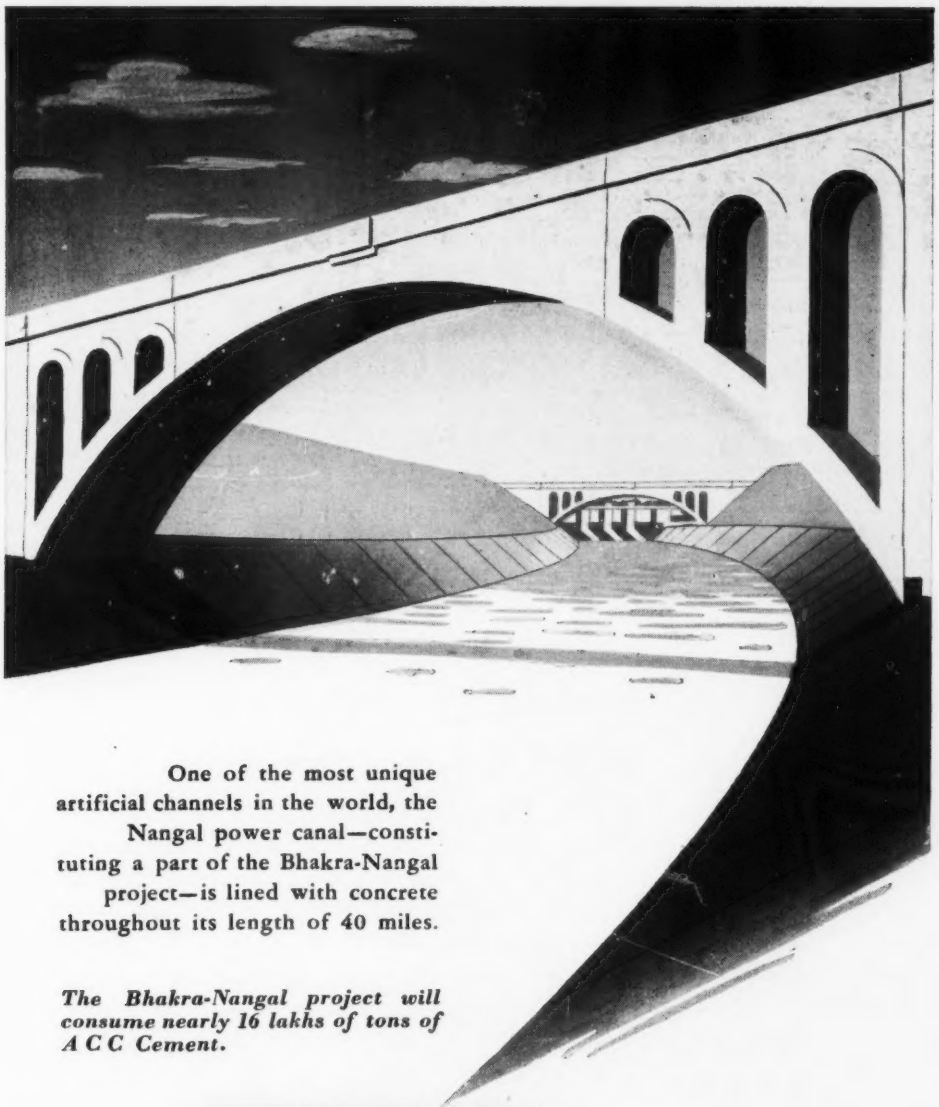

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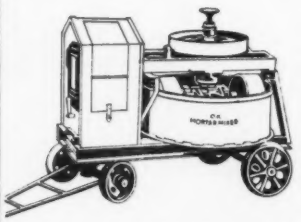

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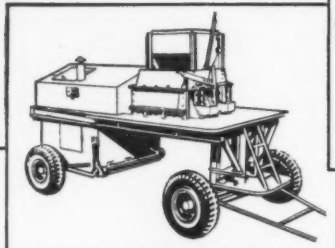

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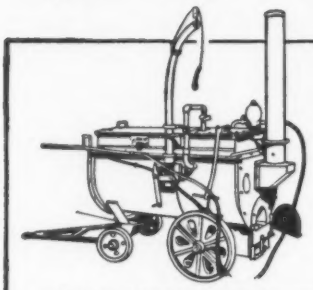

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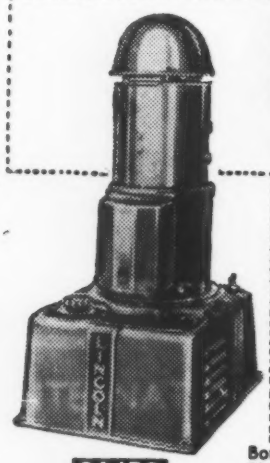

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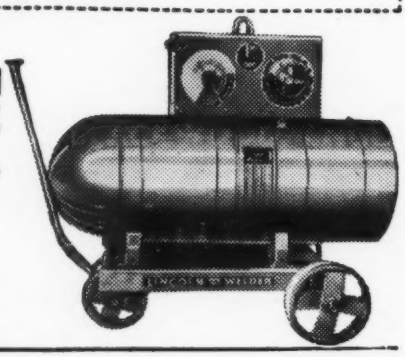

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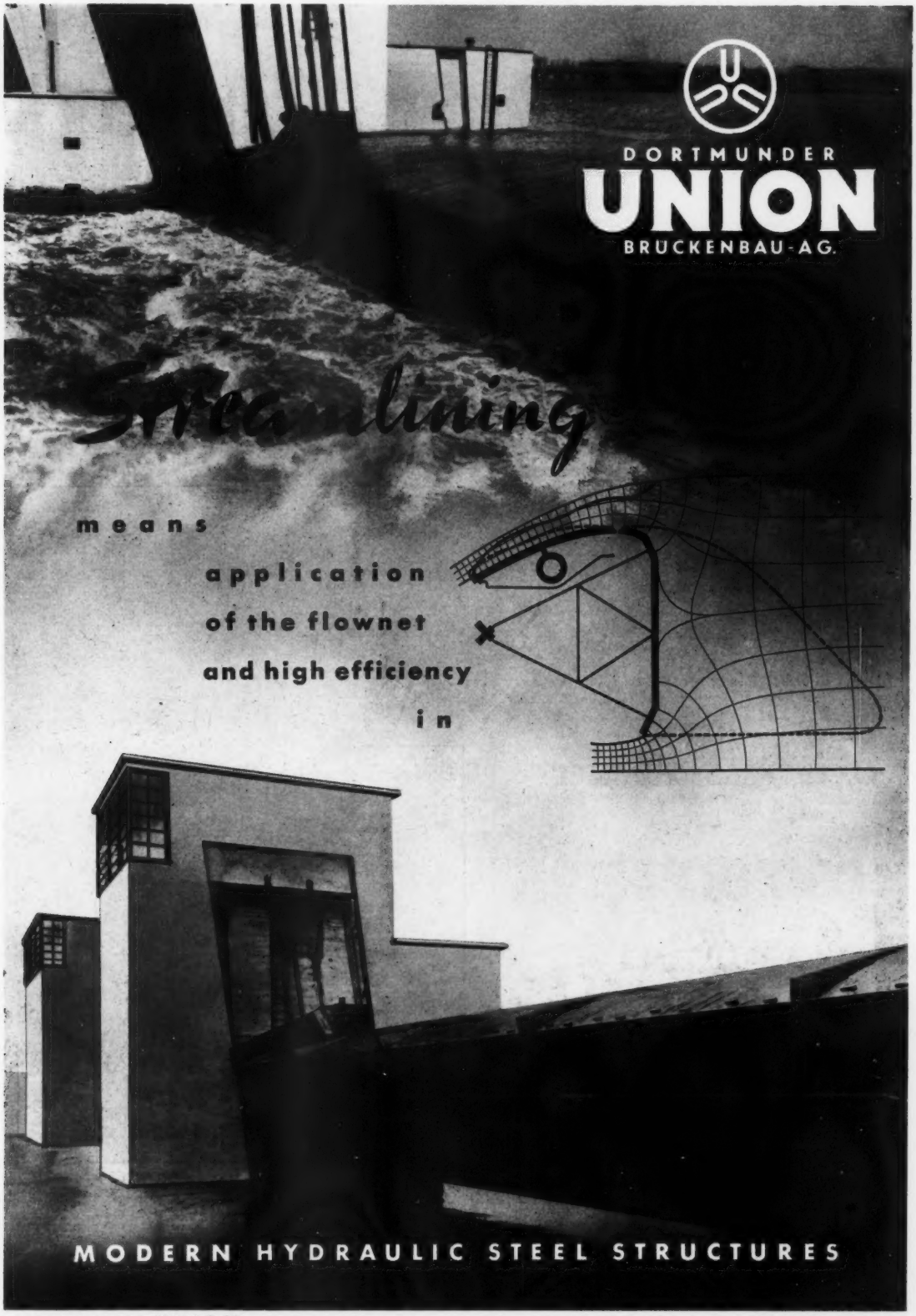

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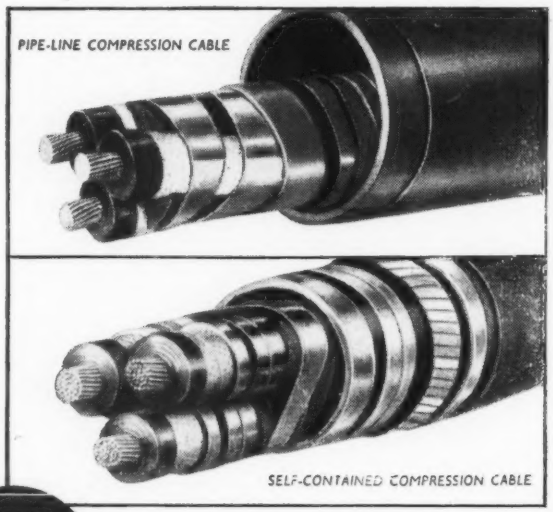

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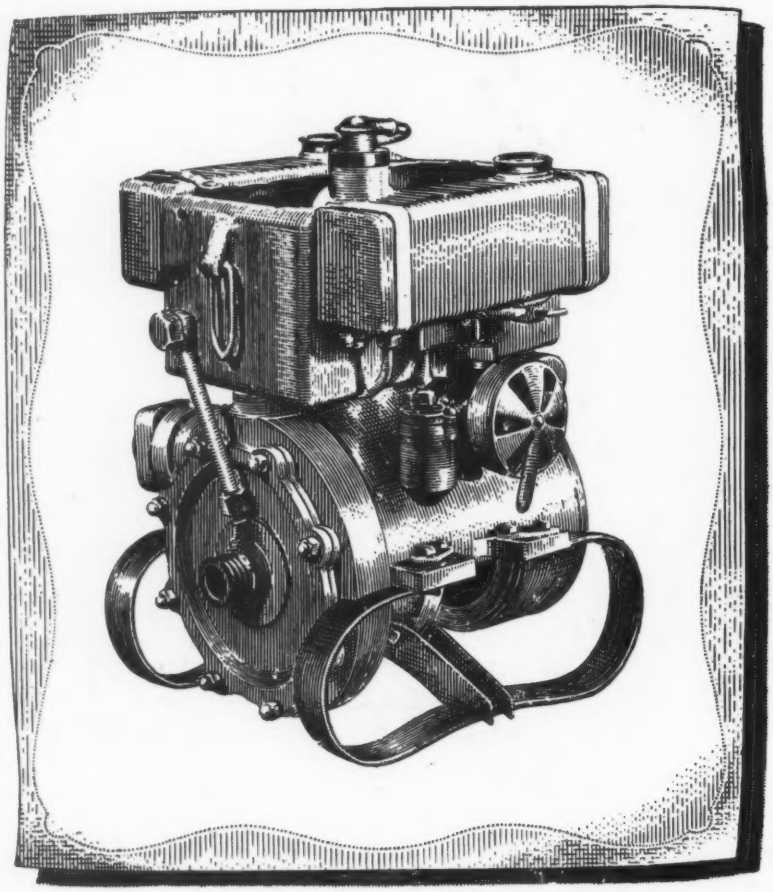

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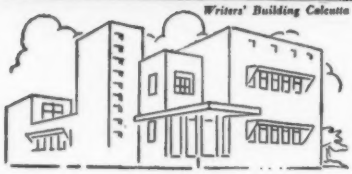

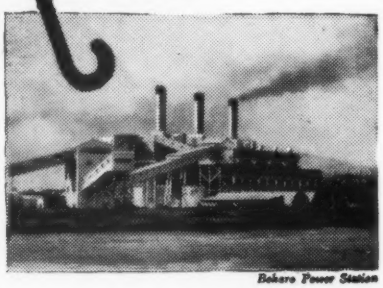

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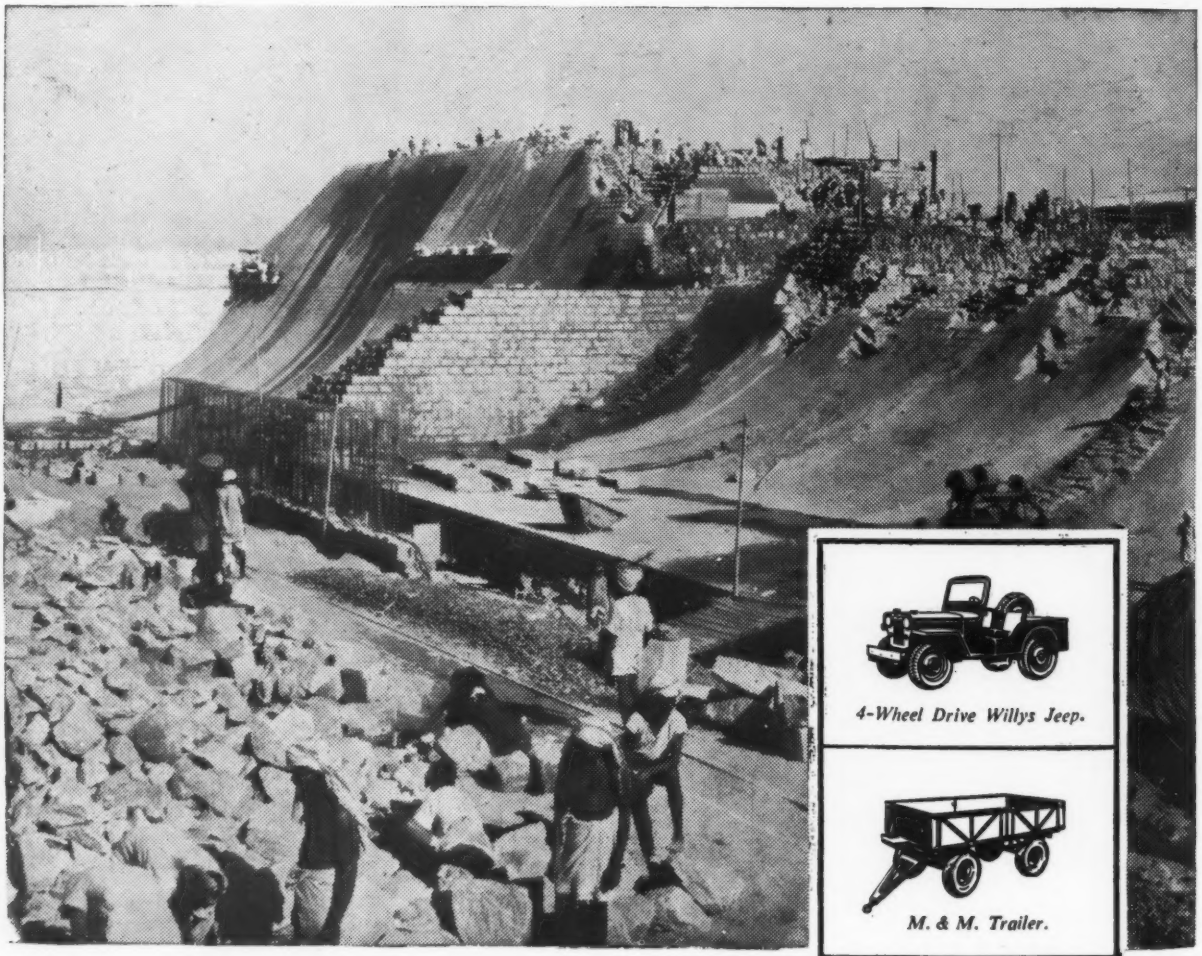

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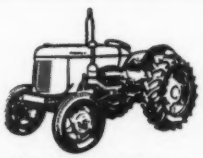
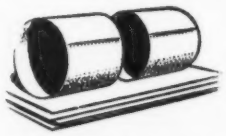


David Brown Tractor.



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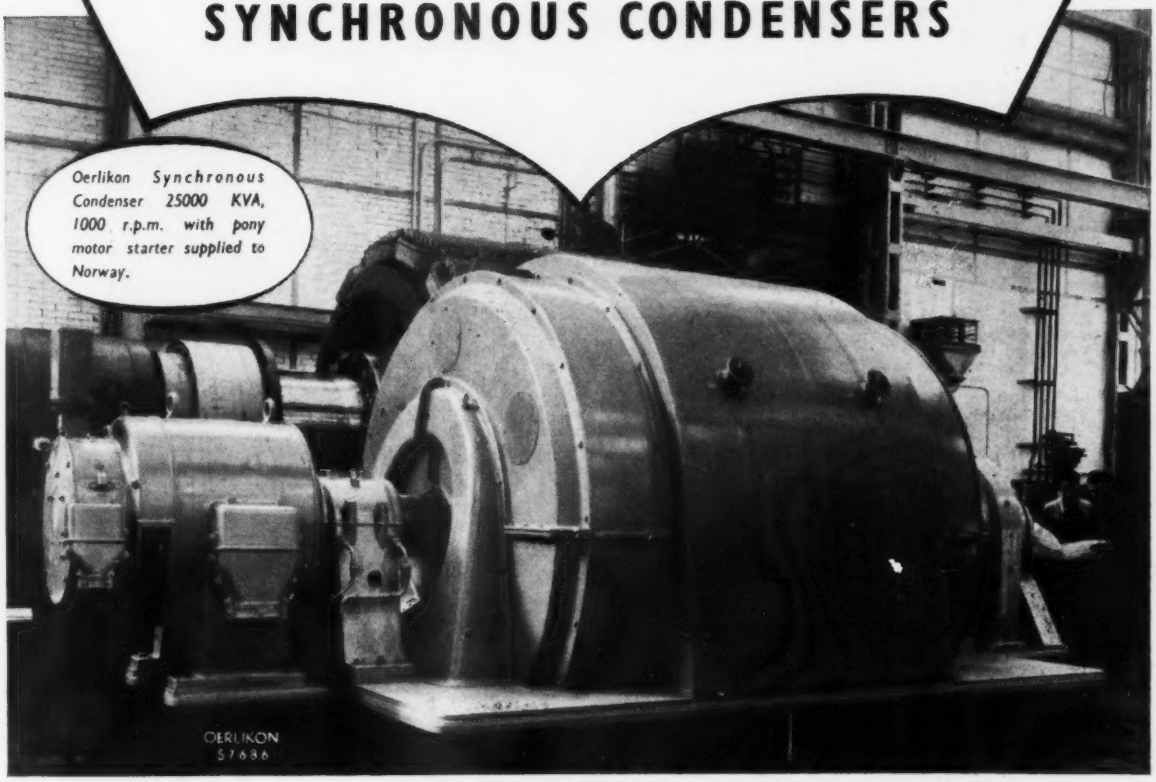

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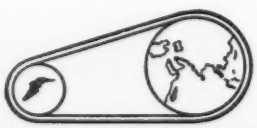

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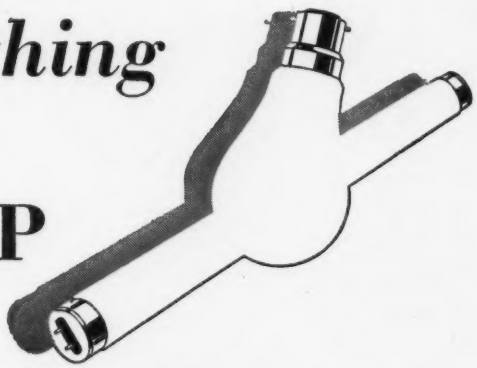

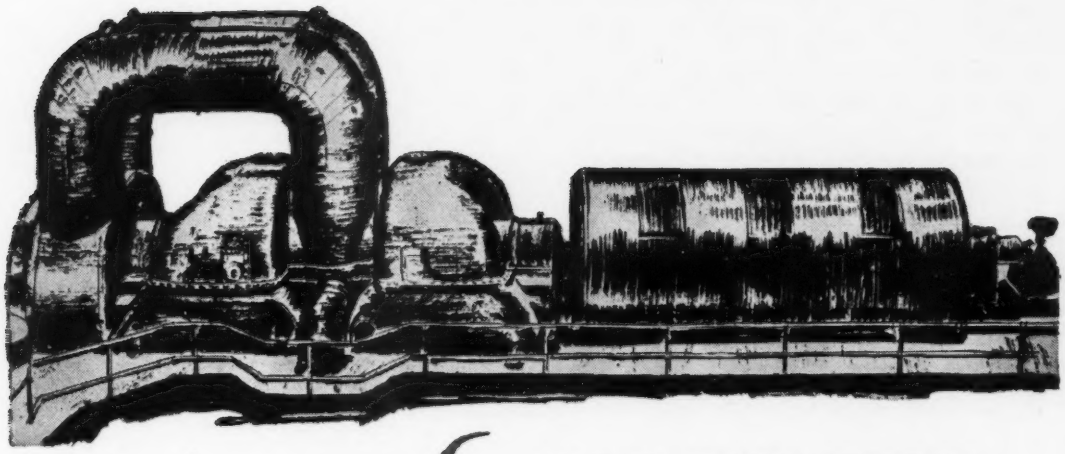

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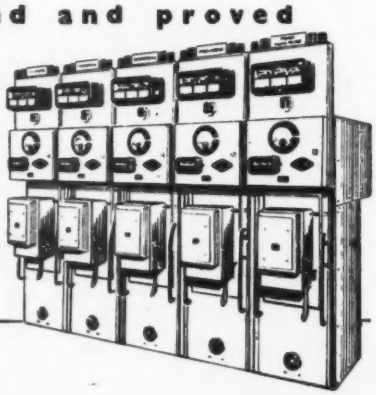

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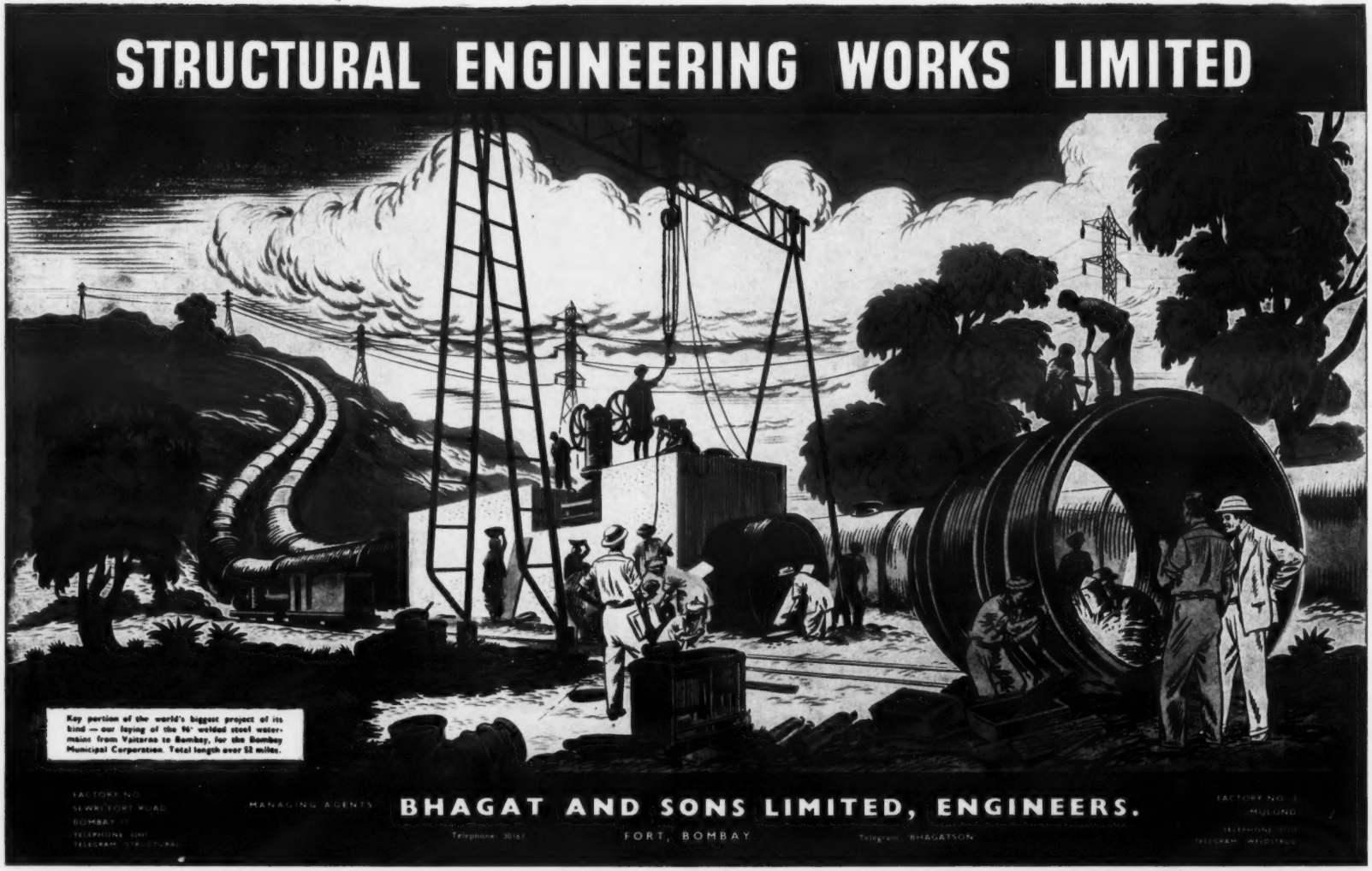
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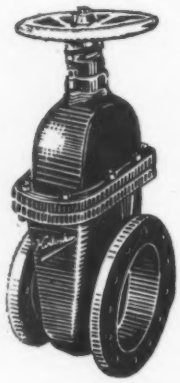

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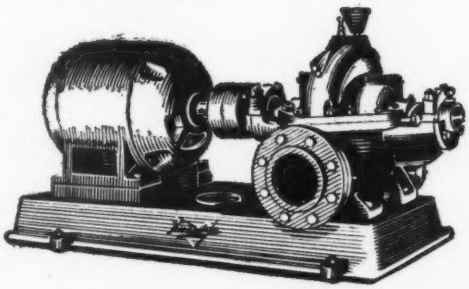

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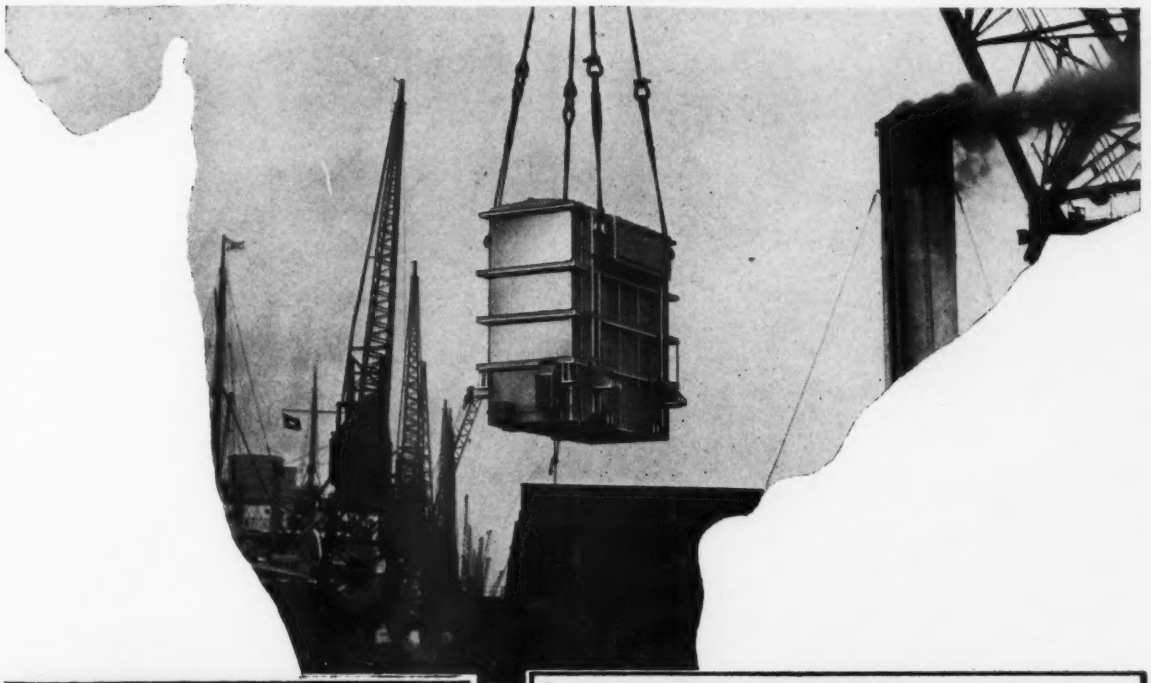

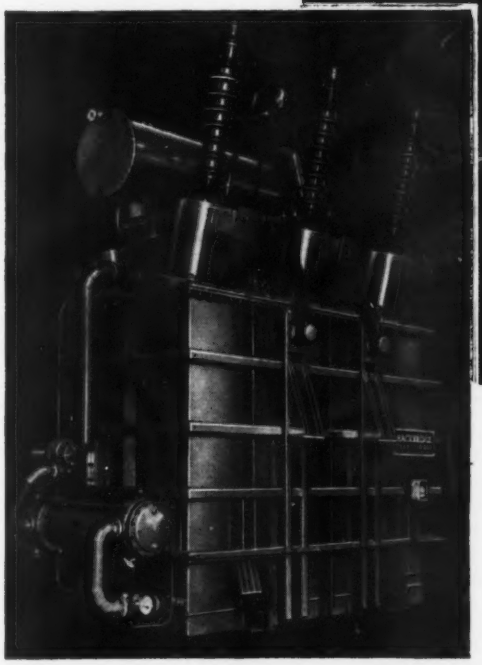

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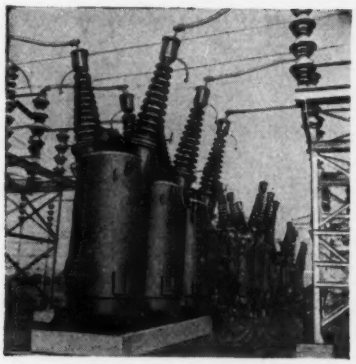
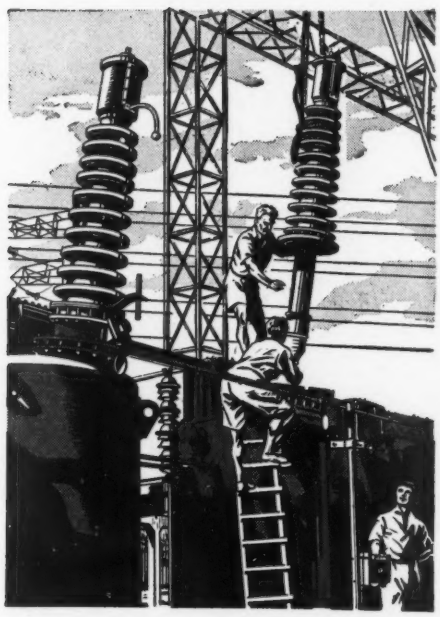


Type XOPR54 Circuit Breakers *in situ*



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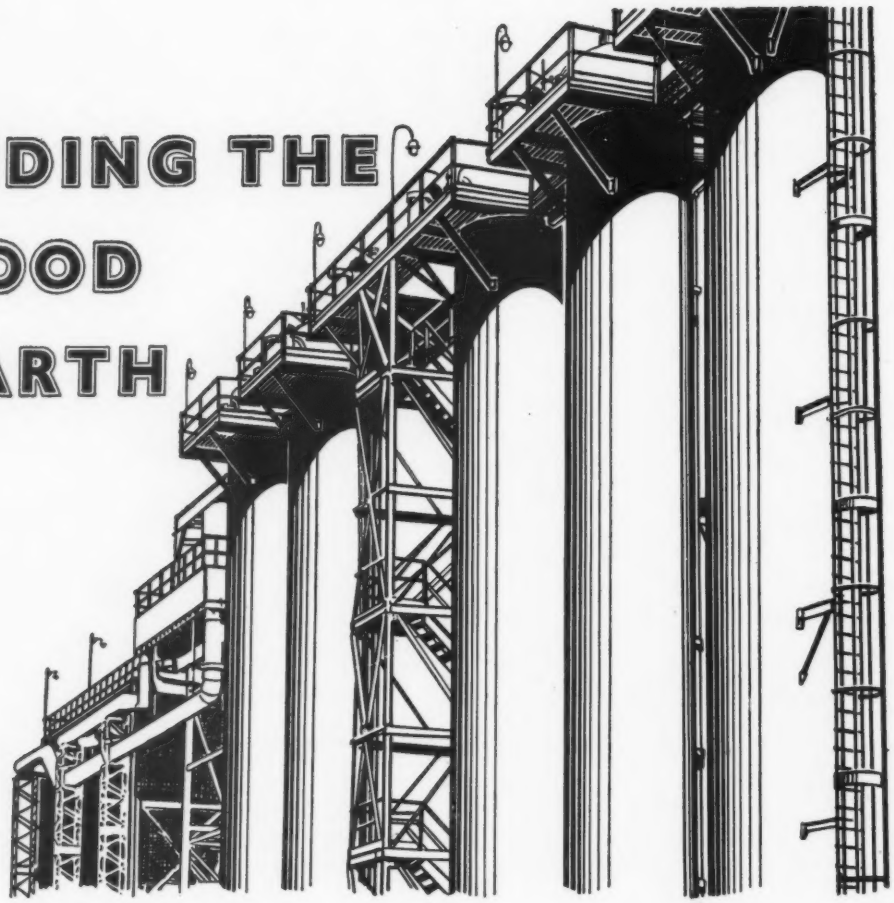

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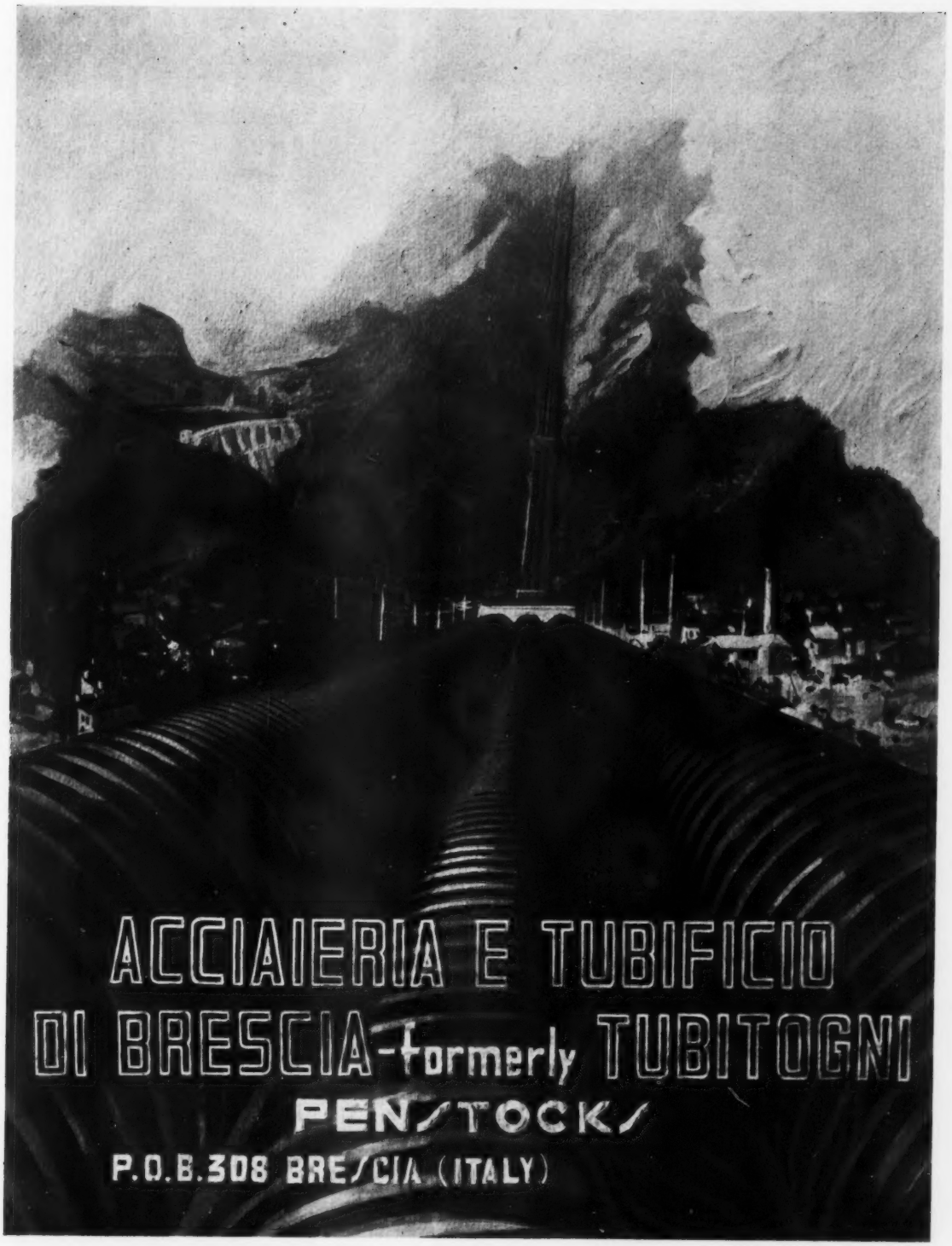
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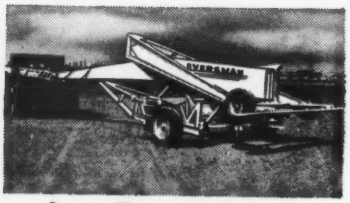

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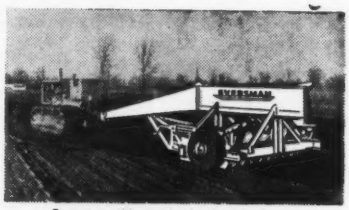

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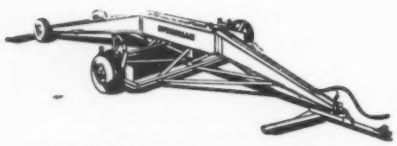
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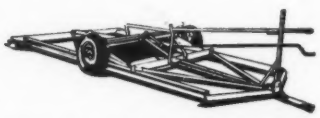
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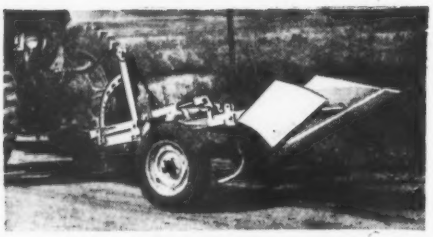

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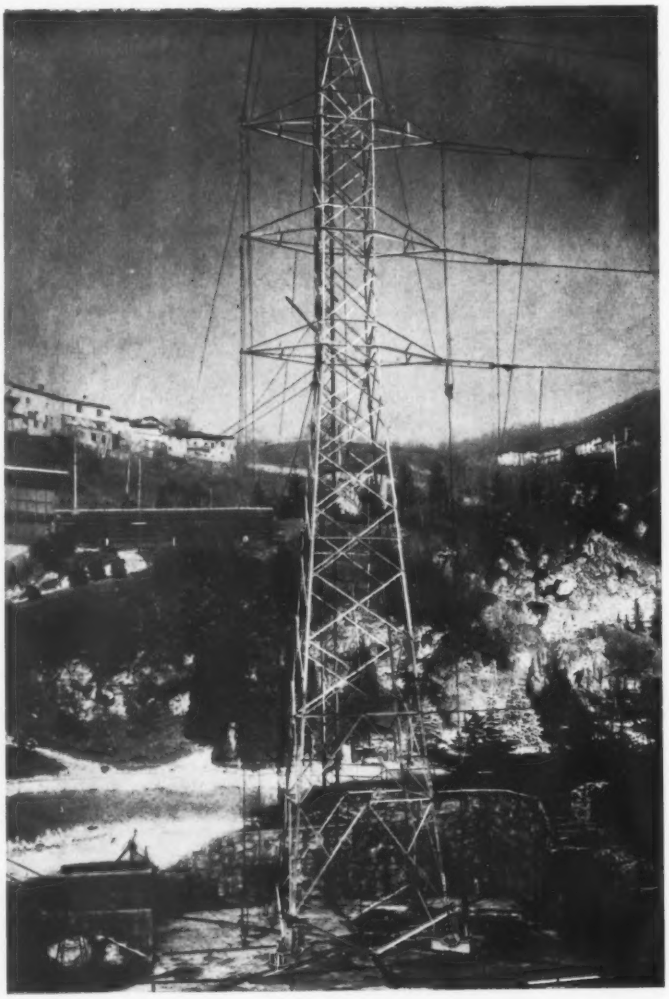

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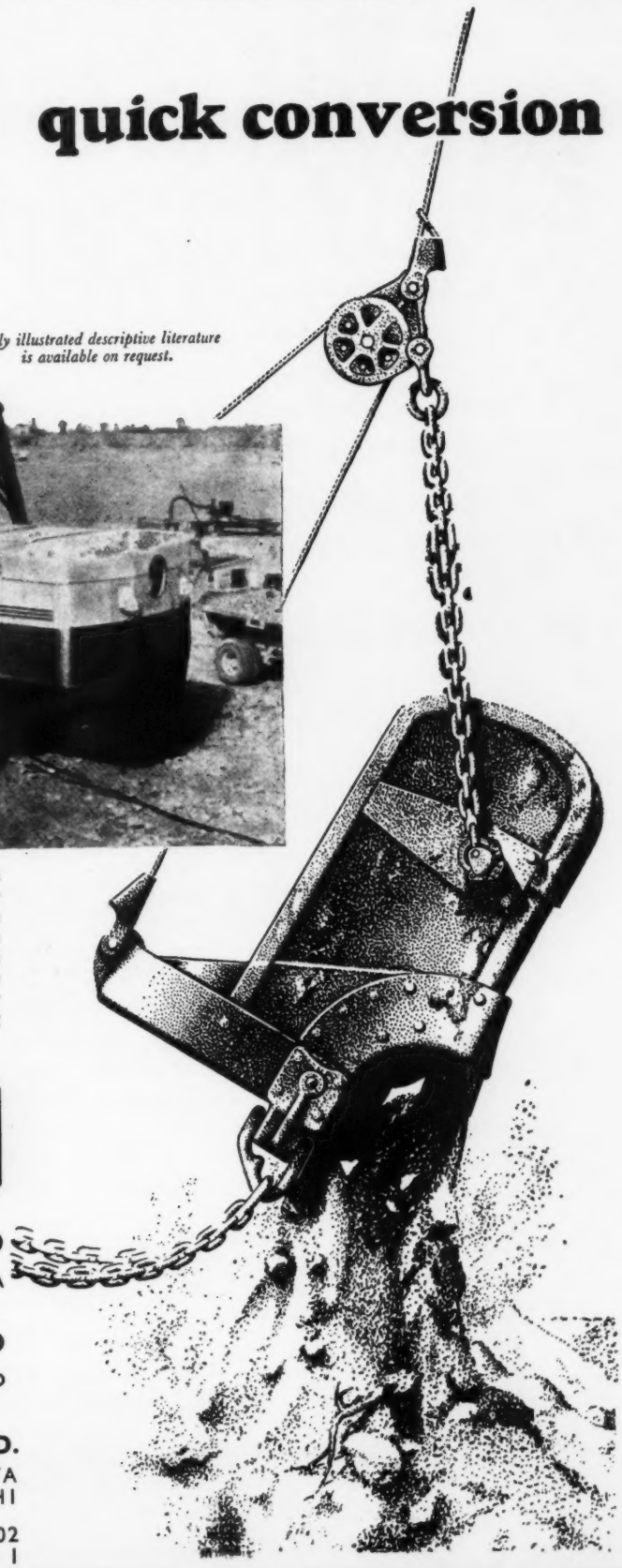

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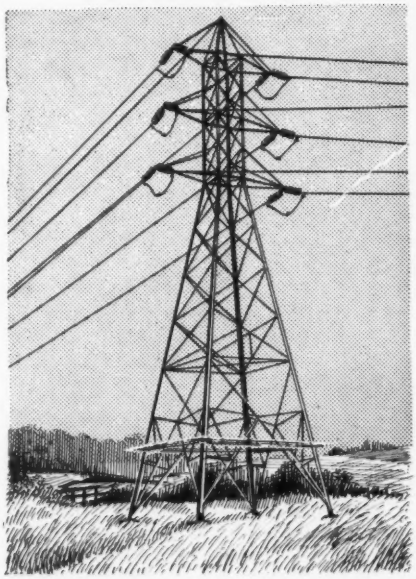

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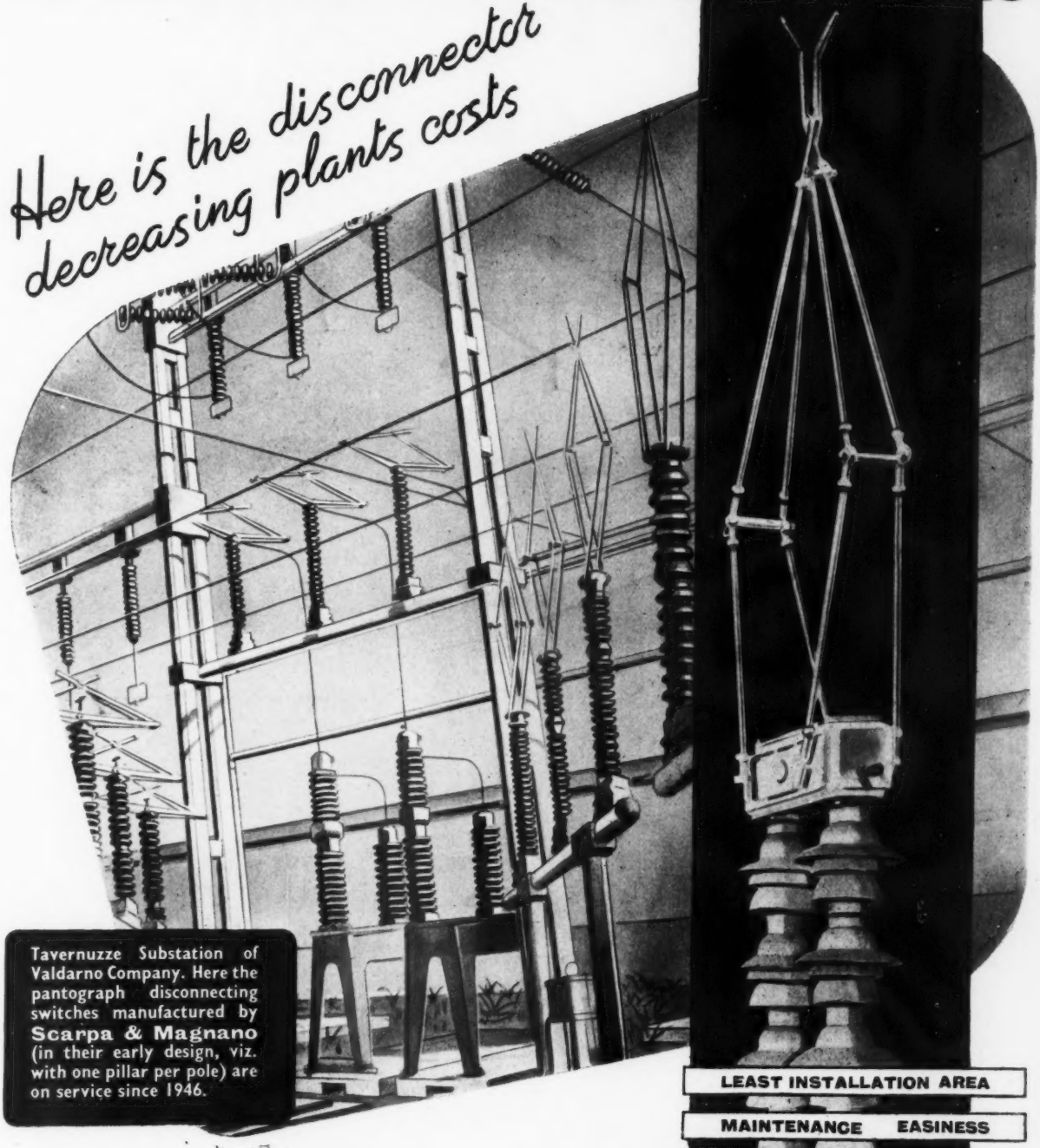
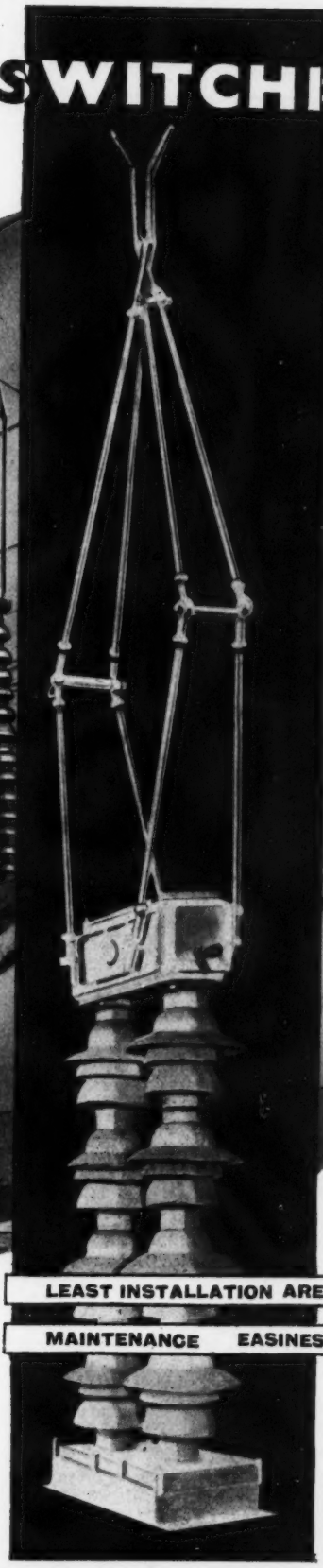


Tavernuzze Substation of Valdarno Company. Here the pantograph disconnecting switches manufactured by **Scarpa & Magnano** (in their early design, viz. with one pillar per pole) are on service since 1946.



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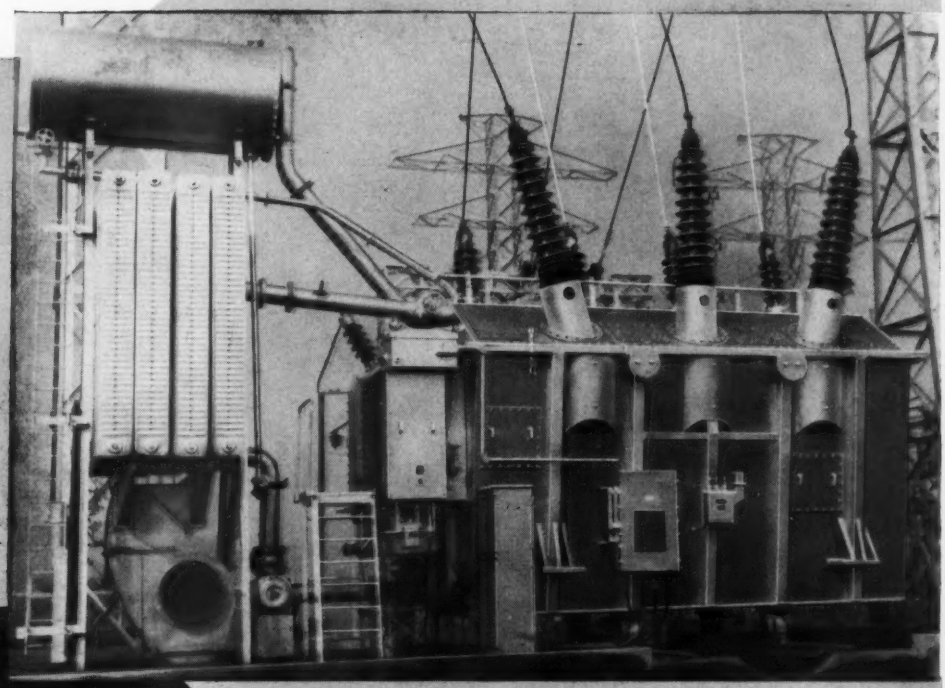

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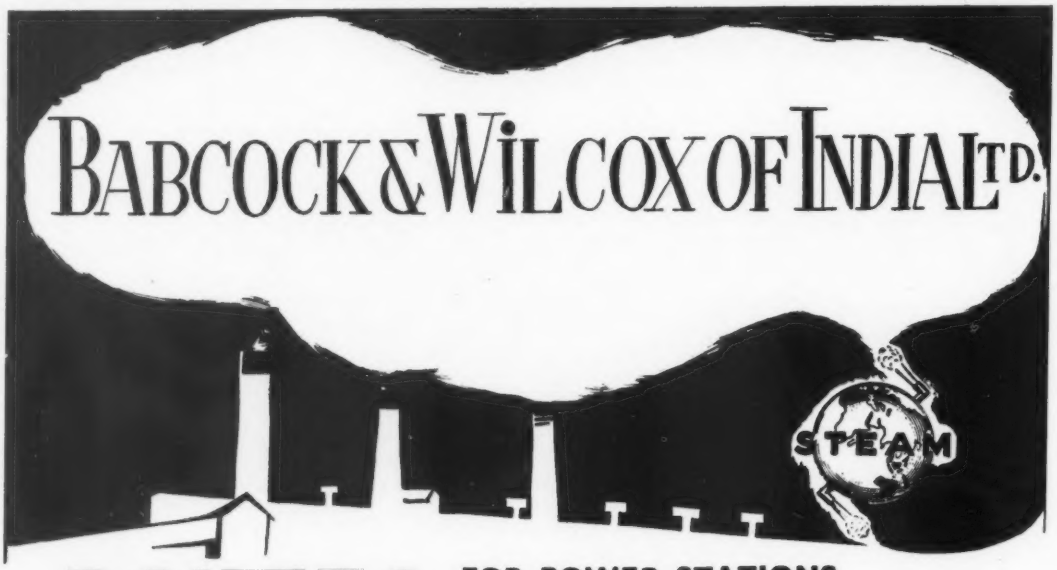

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Editor : **K. K. Sinha** **P. K. Menon** : Mg. Editor

Vol. V **DVC Special Number : June, 1955** **No. 6**

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COVER : A VIEW OF THE BOKARO POWER STATION

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What is the D. V. C. ?

P. S. RAU

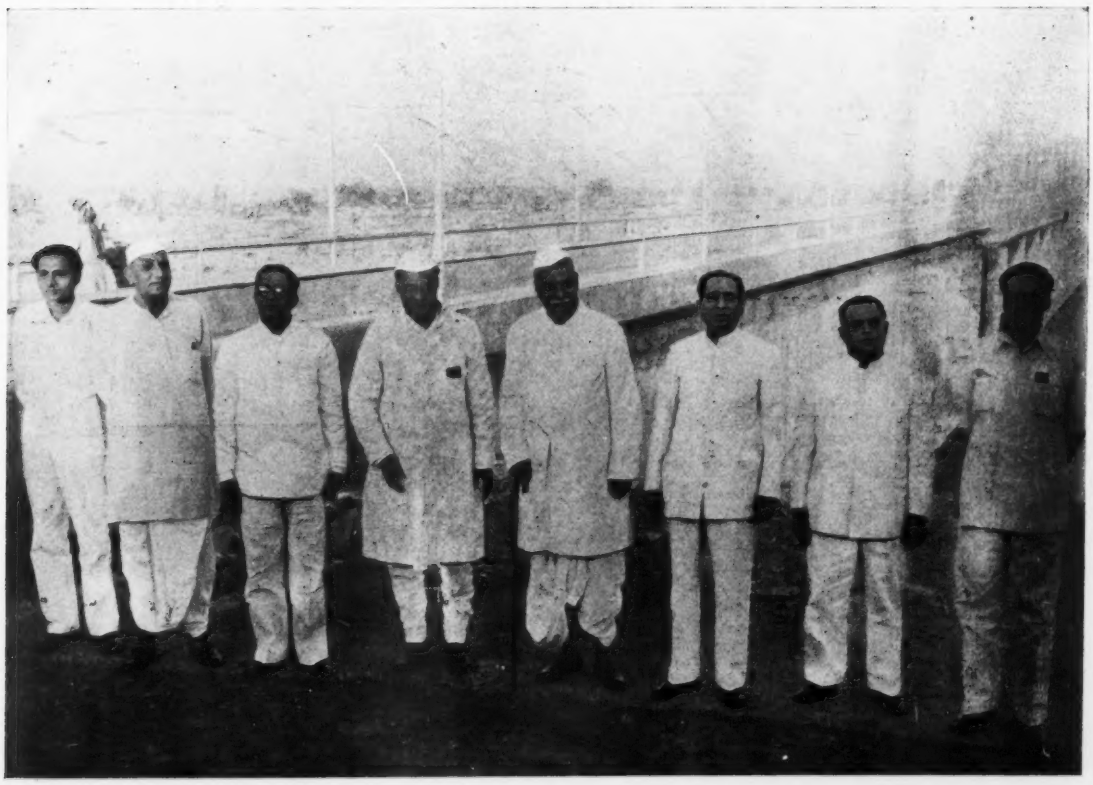
The Damodar Valley Project taken up for execution immediately after India attained independence symbolised the beginning of the constructional phase of India's post-independence era. It therefore rightly caught the imagination of the people of the country. It also represented a new departure from the traditional practice, because of the fact that for the first time in India an integrated and unified programme of river development was taken up on a basinwide scale through an autonomous agency on the lines of the T.V.A. which was already popular in this country. The Damodar Valley Project and its operating agency, the DVC, therefore, occupy a unique place in the mind of the people as a novel experiment in this land, although from the point of view of magnitude or complexity it is outstripped by several other projects. It is, therefore, natural that the public is anxious to follow its progress and problems. The following pages will provide a vivid picture of both and thus will help in the formation of an independent opinion. This first contribution by the Chairman of the DVC initiates the series of authoritative contributions.

AUTHOR

The history of independent India during the last eight years is really the history of its development projects and it is at once heartening and surprising that India has done more work and achieved greater progress during the last eight years than she had done during the previous 150 years. The progress is not confined to any one aspect of our national life, but extends to every facet of it, whether it is river valley development or electricity generation and transmission, whether it is large scale industries, the manufacture of iron and steel, machine tools, or air-craft, the improvement of agricultural methods, soil conservation, crop planning, higher education, research, expansion and increase in the number of public health and medical institutions; whatever we can think of, much solid work has been done, although of course much more remains to be done. After all eight years or even 80 are a mere nothing in a nation's existence.

In these developmental plans river valley projects naturally occupy a place of pre-eminence because more food is the first requisite of India, and more food can only be grown by means of irrigation; and one of the primary functions of the river valley projects is to provide irrigation. Among the river valley

The President, Chairman DVC, Members DVC, F.A. at Tilaiya



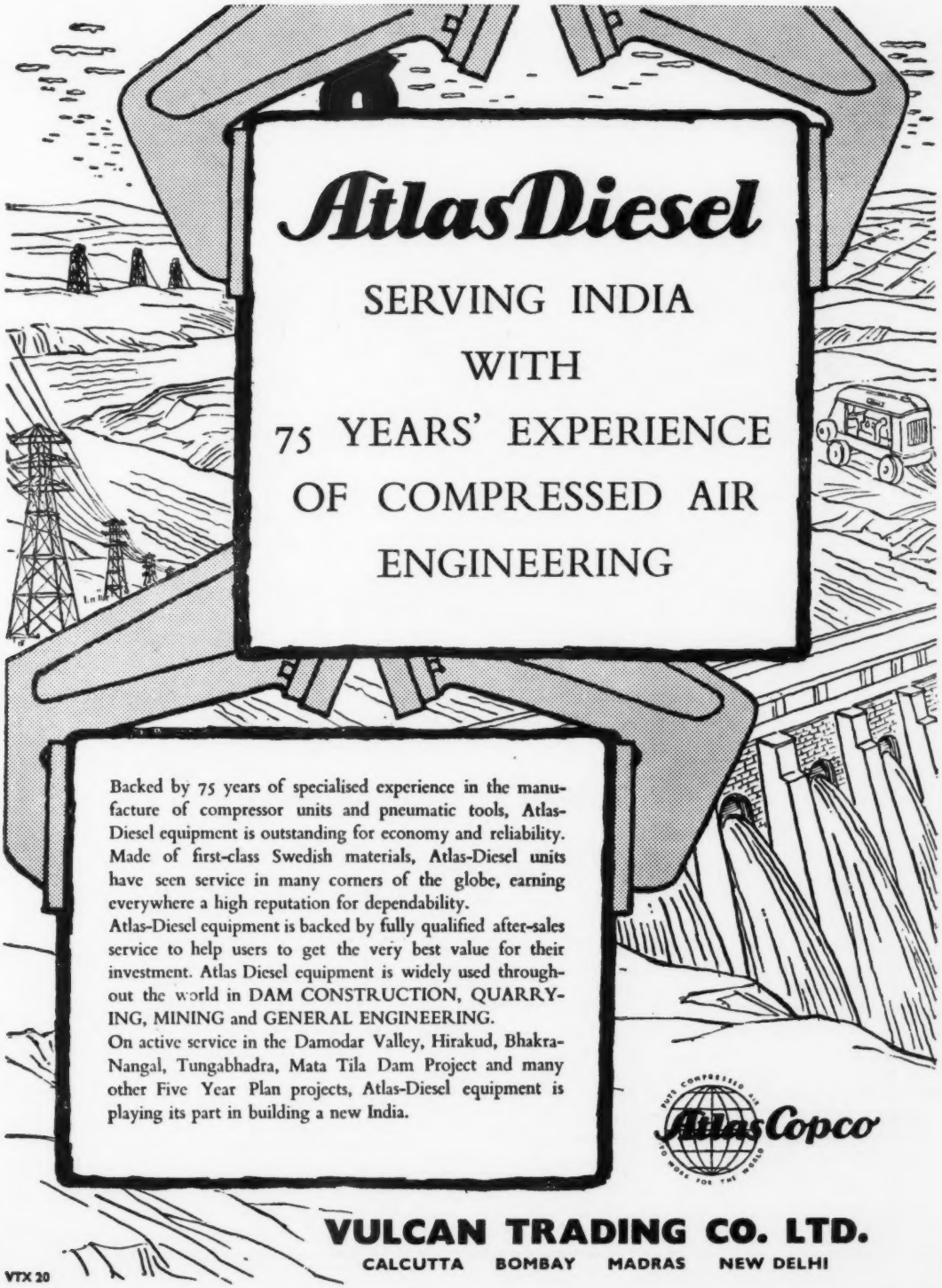
projects, the Damodar Valley Corporation not only occupied the pride of place, being the first of its kind, but it is unique in that it is the very first attempt in India to translate the American conception of the integrated development of the entire resources of a river basin. As is well-known, this idea was first implemented in the United States when they tamed that wayward river, the Tennessee, through the agency of the Tennessee Valley Authority which, in the words of the late President Roosevelt, "combined the authority and prestige of Government with the elasticity and freedom of private enterprise." Although owing to various circumstances beyond human control, the course of the DVC unfortunately did not run smooth in the early years, yet we need not be ashamed of the achievements of the organisation. As has been generally recognised, most of the difficulties have since been overcome, most of the obstacles have been surmounted and a great deal of solid achievement stand to the credit of the DVC today. Two dams, one on the Barakar at Tilaiya and the other at Konar have been completed. A mighty dam at Maithon also on the Barakar is nearing completion. The construction of the Panchet Hill Dam on the Damodar itself is in full swing. The Barrage at Durgapur on the Damodar has been completed and irrigation canals are being rapidly constructed, although it will take another two or two and half years to complete them. Perennial irrigation over extensive areas will then be possible. Floods will soon be almost a thing of the past.

A beautiful thermal station capable of generating 1.5 lakh kW has been set up at Bokaro and has been supplying electricity not only to various large consumers in the Valley itself, such as the Indian Iron and Steel Co., Burnpur, Chittaranjan Locomotive Works, the Telephone and Cable Factory at Rupnarayanpur, not to speak of various engineering industries and the coal mines, but also outside the Valley, such as the Tata Iron and Steel Co. at Jamshedpur and the Ghatshila Copper Mines, etc. Power is already being supplied to various places in Bihar and will go in a short while to Gaya, Patna and Dalmianagar. Although in the beginning our gloomy prophets confidently predicted that the DVC power would be a glut on the market, it is already clear that it will be in short supply in three or four years. Plans are therefore being laid to extend the system and sanction of the authorities is being sought.

A less spectacular, but nonetheless vital, activity of the Corporation is agricultural improvement and soil conservation. The Corporation holds that soil conservation is next in importance only to the dams themselves and is therefore determined to do something substantial in this direction. Agricultural development is equally urgent and is receiving attention. There is already a demonstration and research farm for the upper valley and one is shortly to be opened near Panagarh to serve the needs of these tracts that stand to benefit from our irrigation.

I personally consider myself fortunate to be associated with a national project of this magnitude.

Tilaiya Dam (upstream).



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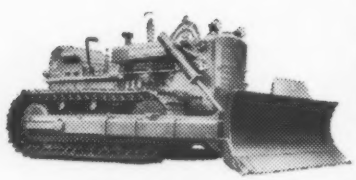

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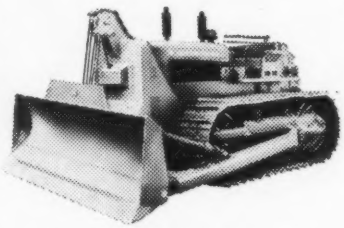
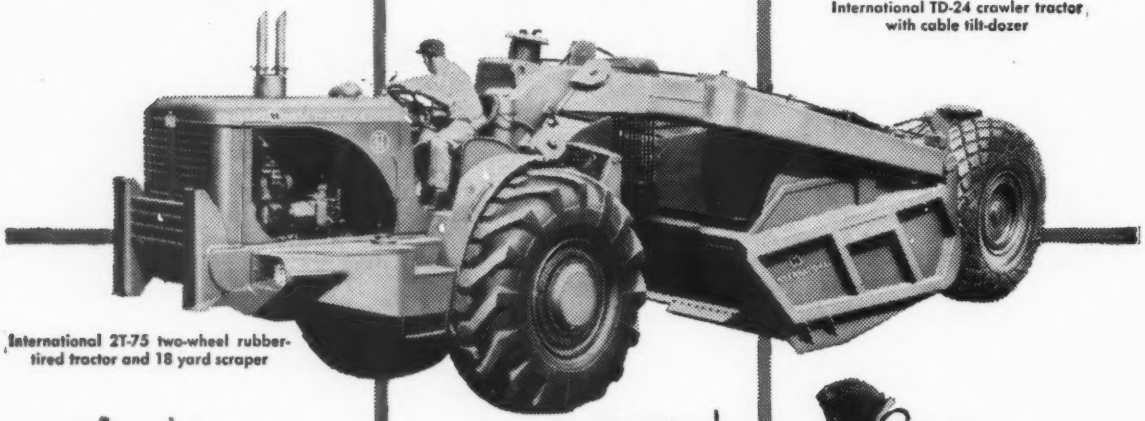
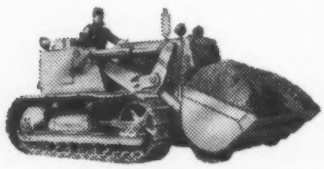
International B-250 four-wheel scraper for use with the TD-24 tractor



International TD-24 crawler tractor with cable tilt-dozer



International 2T-75 two-wheel rubber-tired tractor and 18 yard scraper



International TD-14A crawler tractor with hydraulic skid-shovel

International 2T-75 two-wheel rubber-tired tractor and bottom dump wagon

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Some Thoughts on the D. V. C.

P. P. VARMA

AUTHOR

The author of this article is the only continuing member of the Damodar Valley Corporation ever since its inception in July 1948. As such he is fully aware of the initial problems and difficulties that the DVC had to face not only in setting up the engineering organisation at a time when competent trained men were almost scarce, but also in simultaneously meeting the prejudices and administrative resistances from several quarters, both public and governmental, due to the fact that the DVC represented a new type of authority. The article provides a revealing insight into the mind not only of the DVC authority but also those of the participating governments. The author also ably and boldly deals with the limitations of the DVC Act seriously curtailing the autonomous character of the DVC as well as the range of the purposes of its operation. Coming from a member of the DVC in such a forthright manner, the contribution would thus be of great interest.

Our objective, as defined by the Congress, is to build up a democratic way of life and a socialist pattern of society. I would put the two ideas together and describe it as democratic socialism. We are, however, not sufficiently alive to the need of building up the institutional foundation of democratic socialism. Democratic socialism has to develop its own tools and institutions in order to achieve its objectives.

It is recognised by all progressive thinkers that decentralisation is necessary to save democratic socialism. The State concentrates in itself all the political and military power, and if it concentrates in itself also the economic power, it will become a dangerous Leviathan. This decentralisation, which means devolution of authority, distribution of power and dispersal of initiative, can only be achieved through local authorities, like panchayats, municipalities, co-operatives, district boards, which should participate in the planning and execution of measures of local welfare and through public corporations which may deal with certain special services like the National Coal Board, the British Electricity Authority, the Transport Commission of U.K.—the idea being to separate the administration of these services and other social services of an economic character from the ordinary activities of the Government and run them through public corporations.

In fact the major schemes of the public sector should be administered by public corporations. Of course the composition of the Corporation has to be carefully made.

In U.K. selection of the members of the Board of nationalised industries have been the subject of a great deal of controversy. Two contradictory criticisms have been made. One is that the men who are appointed to the Board are given these posts as a reward for trade union work or political services. The other criticism is that it is still the old gang back again and that the employees expected a radical change of management upon nationalisation and change in the spirit of management and they have been disappointed. It is said that the old gang is still in power. It is almost agreed now that the Board members should have a wide background and a broad perspective because they are not merely concerned with maximising profits and lowering costs, but have a certain responsibility to the community at large. The twelve big Boards in England are manned by 47 full-time and 48 part-time members and it may be said that these 95 men constitute a most powerful group of business management in the Western world. It is also said that the academic and scientific fields have been ignored and persons with professional or legal knowledge have been appointed only in a few cases.

As the public sector expands in India, the selection of Board members assumes a great deal of importance.

If men with wide experience and progressive outlook are employed, the numerous Government undertakings can be handled more efficiently by public Corporations than by departmental method. The Government have not as yet accepted the corporate device as a matter of policy for such activities, but they are being forced to accept the need of public Corporation to run State business. The two Corporations set up to run the air services are a recent example.

Apart from all these, there stand the enormous river valley projects for the execution of one of which the D. V. C. was set up. In the other river valley projects, the Government are refusing to face the logic of the situation and have set up substitutes for public Corporations, namely Control Boards. This shows that Government are being led unconsciously by logic of circumstance to the Corporation idea, but are not willing as yet to accept it as the main instrument for executing such schemes. And D.V.C. remains the only full-fledged public Corporation to execute a river valley project. I feel that particularly for the river valley schemes, public Corporation is the right instrument. A river valley scheme is intended to develop all the resources of a river basin, and to extract from

P. P. Varma *is Member, Damodar Valley Corporation*

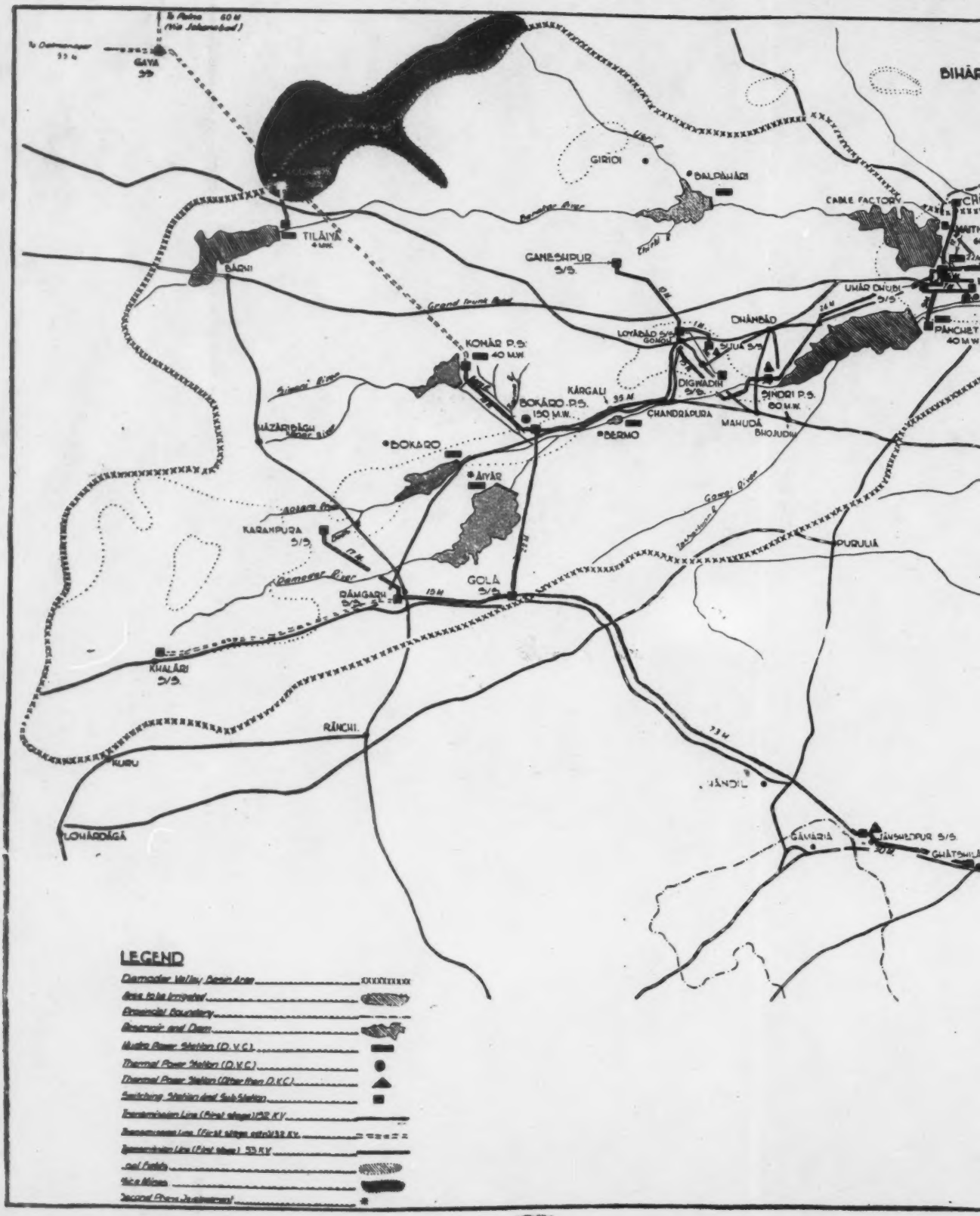
it all the benefits that a controlled river system can confer. Unfortunately this idea of development has with the passage of time receded into the background. D.V.C has been building dams and power stations and irrigation-cum-navigation system, but it has been discouraged to undertake development works. The idea of a multipurpose coordinated development of the resources of the Valley has received a set-back and the present policy as laid down by a Conference of Participating Governments in July last is that the responsibility of D.V.C. should be confined to development activities directly connected with the maintenance of reservoirs and canals and a few small-scale industries after they have been approved by the Government. This amounts to diluting the functions of the Corporation as laid down in section 12 of the D.V.C. Act. and the preamble itself which states that D.V.C. was established for the "development of the Valley". D.V.C. was really set up to develop the resources of the Valley for the social and economic welfare of the people and was entrusted not only with the responsibility for such development, but also with power to discharge it. But this concept has been practically given *coup-de-grace*. This has been unfortunate. I believe that a demonstration of comprehensive river harnessing with its manifold benefits made in this area, would have facilitated water planning in other areas in the light of experience gained here. Regional planning is coming to be recognised as an essential part of an over-all planning; different regions differ in the quality of the soil and in mineral and human resources and a plan that fails to take note of these will not be effective. Multi-purpose river valley projects should give a stimulus to regional planning. I wish D.V.C. had been given more scope and initiative for such activities.

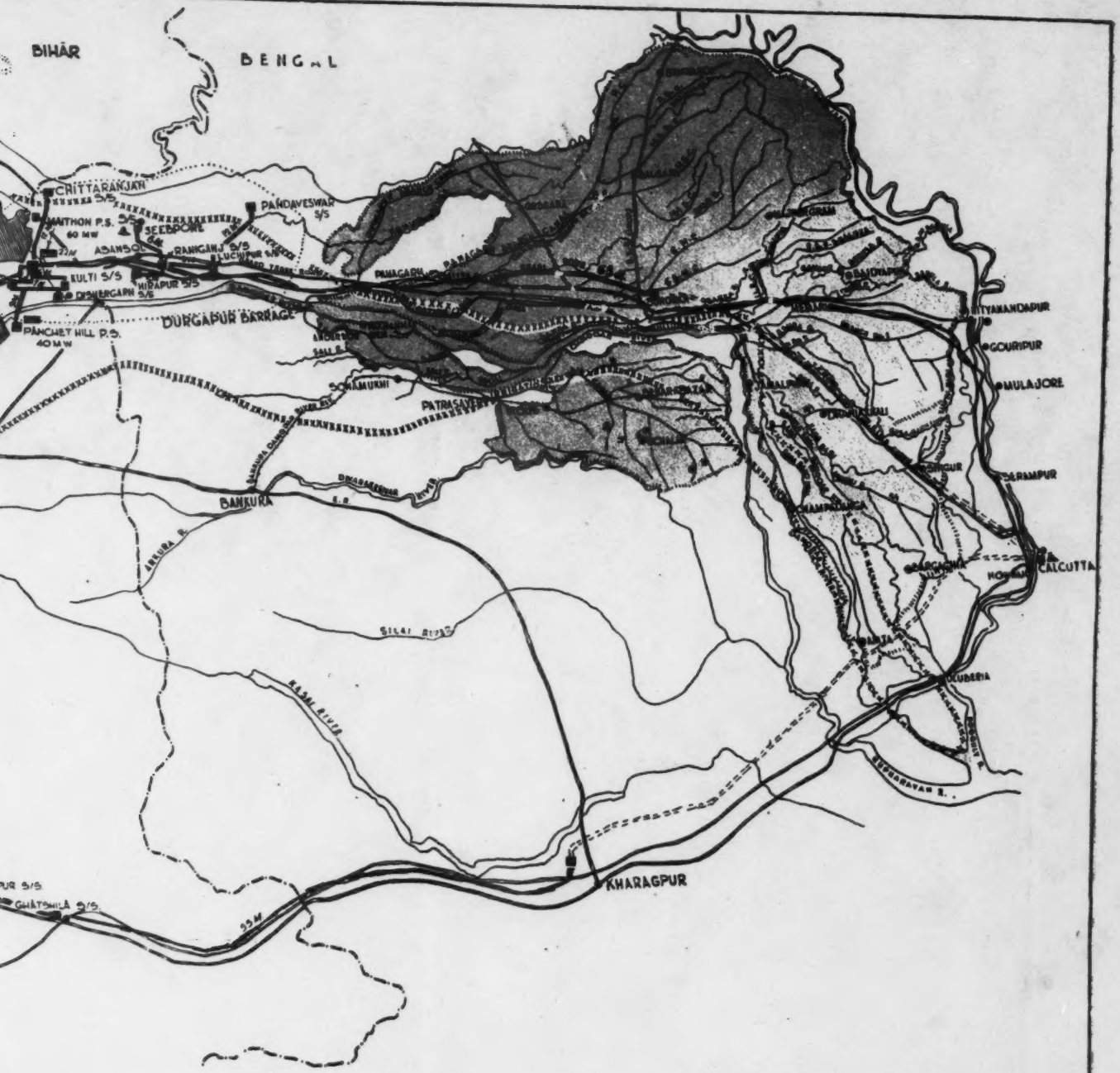
I believe that Corporation method of doing things should prove better than bureaucratic and merely commercial method. It is too early to pronounce an opinion whether D.V.C. as an instrument of decentralised public administration has failed or succeeded. It is the first experiment of its kind. If it has failed in some respects, the causes of failure should be analysed and removed, and not the idea itself abandoned. But progress so far achieved by D.V.C. during the last seven years, although in some cases we are behind schedules, has amazed visitors, Indian and foreign, technical men and non-technical men.

There will always be a controversy whether more money has been spent than should have been, but the progress made by D.V.C. has not been questioned by impartial observers. It requires a great deal of prejudice not to be impressed by the progress. In assessing the progress in seven years, one should remember that D.V.C. had to start from a scratch. We had to give a lot of time in setting up a huge organisation, in assembling men and materials, in building roads and bridges and construction camps and in equipping our colonies with water and power. Our colonies are planned to be small towns with modern amenities. Before construction started, all kinds of data had to be collected and designs had to be prepared. The actual construction started in 1950 and during the last five years, we have constructed two dams, Tilaiya and Konar; and Konar involved pouring of more than four hundred thousand cubic yards of concrete and placing of about 55 lac cubic yards of earth. Maithon dam will be completed by the middle of next year and Panchet Hill a year later. We have completed Durgapur Barrage and the entire system of canals and distributaries will be completed by 1958. We have already excavated about two and a half crore cubic yards of earth, apart from constructing a large number of structures including bridges, locks, regulators etc. We have completed the three units of Bokaro Thermal Power Station, each unit of 50,000 kW. We have built about 300 miles of 132 k.V. lines and 32 miles of 66 k.V. lines and construction of another 60 miles is progressing. We have built 70 miles of 32 k.V. lines also. By mid 1958, according to our construction schedules, the entire transmission system including extensions to Calcutta on the east and Gaya, Dalmianagar and Patna on the west is expected to be completed. Although there is a time-lag between the generation of power and sale of power, all our power is booked, and more generating capacity will have to be created to meet the growing demand. Sixteen sub-stations have been constructed and commissioned and four are under construction. And altogether there would be 29 sub-stations.

And within the limited scope of development, we have done some pioneering work in Soil Conservation, which Mr. Parker, the T.C.A. expert, thinks should be an example to the rest of India. We have planned to build a number of small industries, a few of which we are implementing. We are developing fisheries. I should say that we have not done badly during these few years. And I would therefore plead for giving the Corporation method a fair trial and extending it to other river valley projects. It is quite possible that we might have done better.

So far as the question of costs is concerned, it can only be settled when most of the dams in the country are completed and we are in a position to compare costs by same uniform standard. As for instance, it has been held that the cost of the Konar dam is on the high side, but unless we know that dams of similar dimensions have been built at a lower cost under similar conditions we shall not be in a position to make a definite pronouncement. It has been said our estimates have been exceeded. That is true. But the first estimate that we submitted three years ago was about Rs. 80 crores. It is now Rs. 100 crores. This is an increase by 15 per cent. I do not want to defend imprecise preparation of estimates. But certain unforeseen factors have also to be considered. And in order to criticise this excess, we will have also to consider by what percentage the estimates of other schemes have been exceeded. I do not want to suggest that we should go wrong, because other people have gone wrong. But a comparison would make us see things in proper perspective.


GAYA
GIRIDI
BALPAHARI
CAKE FACTORY
TILAIYA
BARNI
GANESHPUR S/S.
Grand Trunk Road
UMAR DHUBI S/S.
DHANBAD
PANCHET 40 M.W.
KONAR P.S. 40 M.W.
LOYABAD S/S
SIJUA S/S.
DIGWADIH S/S.
KARGALI
BOKARO P.S. 150 M.W.
CHANDRAPURA
MAHUDA
BHOJUDIH
BERMO
BOKARO
ANDAR
KARANPURA S/S.
PURULIA
RAMGARH
GOLA S/S.
KHALARI S/S.
RANCHI
KURU
HANDIL
GAMARIA
TATANAGAR S/S.
LOHARDAGA
LEGEND
Damodar Valley Basin Area
Area to be Irrigated
Reservoir Boundary
Reservoir and Dam
Hydro Power Station (D.V.C.)
Thermal Power Station (D.V.C.)
Thermal Power Station (Other than D.V.C.)
Switching Station and Sub Station
Transmission Line (First stage) 132 K.V.
Transmission Line (First stage extn) 132 K.V.
Transmission Line (First stage) 33 K.V.
Coal Fields
Mica Mines
Second Phase Development



DAMODAR VALLEY AND OPERATIONAL AREA

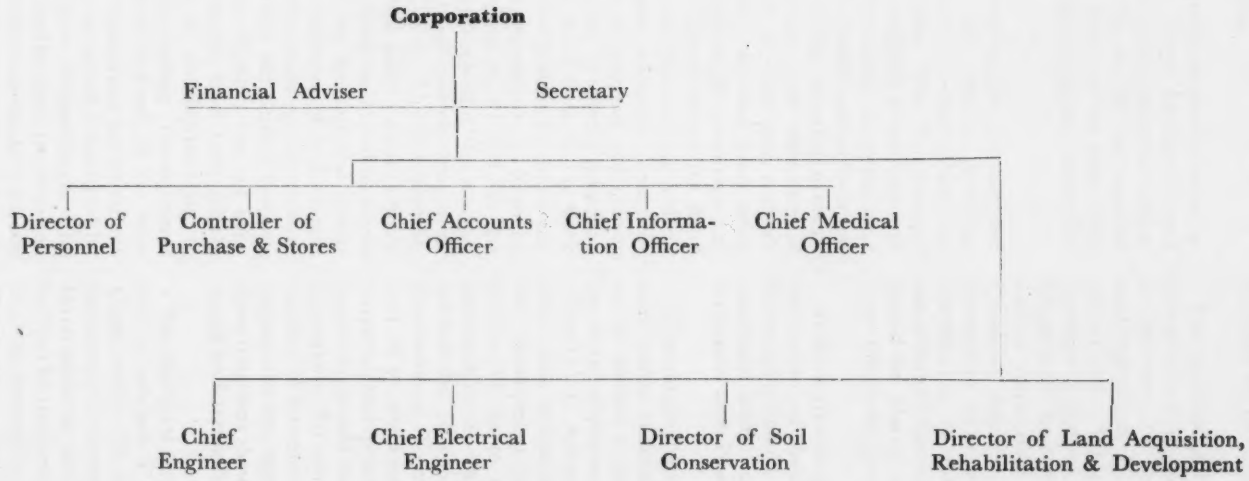
MAP SHOWING PROGRAMME OF DEVELOPEMENT

SCALE. 1 INCH = 9·5 MILES.

facing page 4

DVC Organisation Chart

March 1955



I submit that when after a few years, the total picture of the various river valley projects is available to us, the D.V.C. will not suffer in comparison either with regard to cost or progress.

I do feel that public Corporations should be set up not only for all major State industries—and increasingly the responsibilities for industrialisation will fall on public sector—but for the development of the resources of a river basin on the same lines as the D.V.C. with some of vagueness and anomalies in the Act removed.

I shall now very briefly touch on the structure and functions of the D.V.C. and certain problems associated with them and try to show where the anomaly and inadequacy exist. The functions of the D.V.C. are not merely confined to promote and operate schemes for flood control, irrigation and power, but to promote public health and agricultural and industrial welfare of the Valley, as well as to maintain and operate laboratories and experimental stations etc. These functions, it is obvious, are not merely commercial in nature, but they share some of the functions of the Government, for no commercial undertaking would like to invest money for flood control or irrigation or development of the Valley. These responsibilities require initiative, enterprise and drive and a singleness of purpose and cannot be discharged with multiplicity of checks curtailing its autonomy either by the front door or the back door. The D.V.C. Act has provided for the autonomy of the Corporation to a very great extent. Its financial autonomy is assured by sections 30, 31 and 32. But as enormous public funds are involved in this scheme, there should be some checks and controls compatible with the autonomy of the D.V.C. The Government, the Parliament and the public have a right to know that satisfactory progress is being made and money is not being wasted. One of the fundamental checks is that the Corporation in discharge of its functions shall be guided by such instructions on questions of policy as may be given to it by the Central Government. But what is a question of policy has not been defined in the Act. This should have been clearly stated. The accountability of the Corporation to Parliament and the Participating Governments should have been more clearly defined. It has been further provided that the Corporation has to submit an annual report of its progress which is discussed by the Legislatures of the three Governments. The D.V.C. budget is also discussed by these Legislatures. The Government have extensive rule-making powers under section 59 which are administrative in nature. It is clear that sufficient powers have been given to the Central Government to dictate D.V.C. on questions of policy which they consider to be questions of policy, as well as on administrative matters under section 59 of the D.V.C. Act. To confer more powers on them either by convention or otherwise would make a nonsense of autonomy.

Again the regulations made by the Corporation are subject to the previous sanction of the Central Government. This previous sanction should not have been there. Such a restriction affects the flexibility of action by the Corporation.

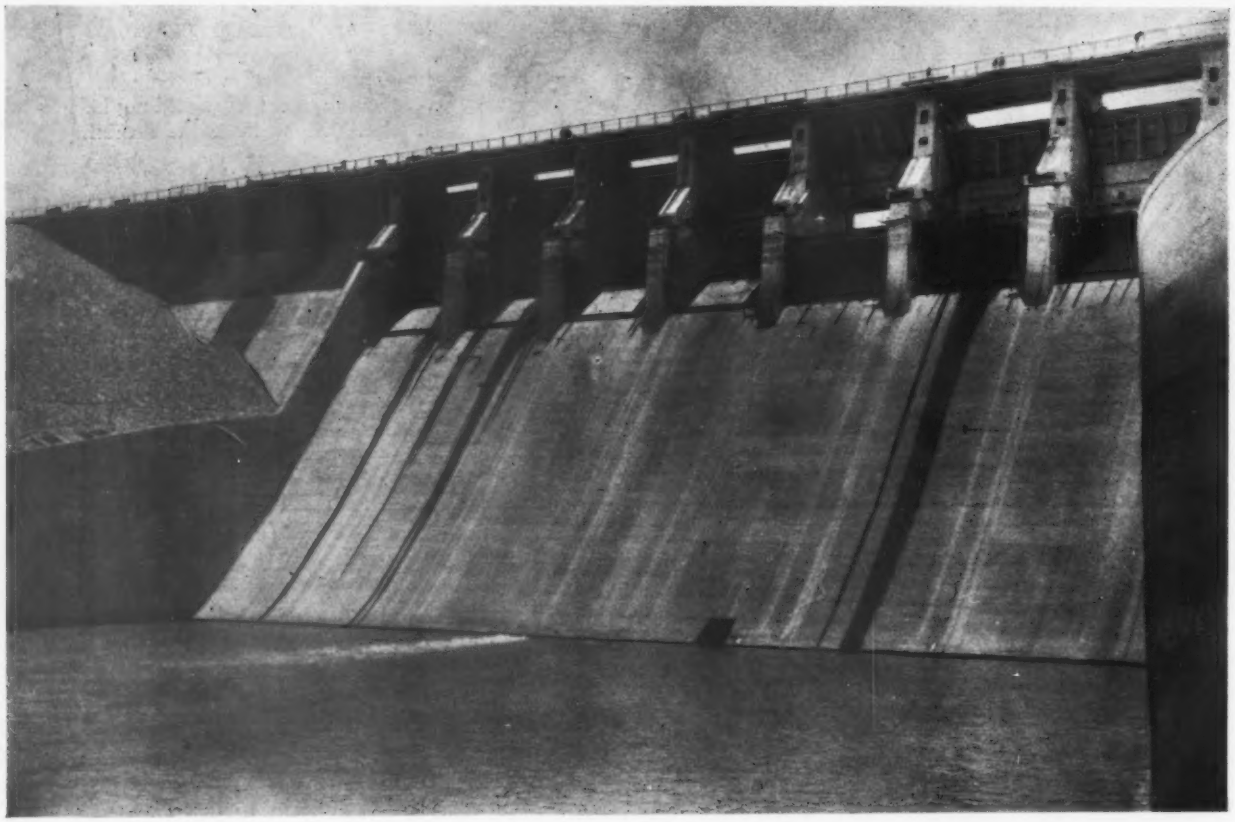
The position of Financial Adviser is somewhat ambiguous. It should have been more clearly stated. In my view, he should be generally responsible to the Corporation. He should have power to vet, but not to veto. What is required is that a high-class financial judgment should be available to the Corporation for every major decision. The Corporation is responsible for its decision and not the Financial Adviser. He has been authorised by a convention to report his disagreement with the Corporation to the Government of India. This is not a healthy convention. But the Finalcial Adviser should be placed in a position which should not deter him from giving his independent judgment.

As the activities of the Corporation are of a manifold nature, it should have been provided that the Corporation should directly deal with the Ministries concerned instead of going through the Ministry of Irrigation and Power.

It should also have been clearly stated that development works undertaken by the Corporation should not be debited to projects. They produce a misleading financial picture. As a matter of fact, section 32 of the D.V.C. Act provides for expenditure on objects other than irrigation, power and flood control and the development activities should be covered by section 32. As to how such expenditure is to be allocated to the Participating Governments can be worked out in consultation with the Participating Governments. To empower the Corporation by Section 32 to spend on objects other than flood control irrigation and power and then to say that such expenditure should only be confined to these objects is anomalous. To entrust the Corporation with a large number of functions and responsibilities and then to suggest that any expenditure incurred in discharge of these functions should be added to the cost of dams would be financially improper and arbitrary.

The financial picture is further blurred by provisions of sections 37, 38 and 39 of the D.V.C. Act. Under section 38, the D.V.C. has to pay interest on the amount of capital provided by each Participating Government at such rate as may from time to time be fixed by the Central Government and such interest shall be deemed to be part of the expenditure of the Corporation. And in fact actual cash payments of interest are being made out of the allotments placed at the disposal of the Corporation. Again under section 37 of the Act, the net profit and net deficit has to be distributed among the Participating Governments with the result that the D.V.C. will be left with no funds to discharge its functions as contemplated under section 12 of the Act. The Participating Governments as shareholders should be entitled to

(*Continued on page* 29)



Concrete dam (downstream face), Konar.

Earth dam, Konar

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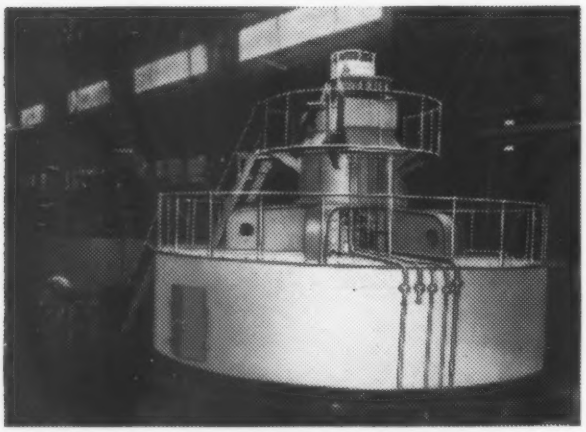

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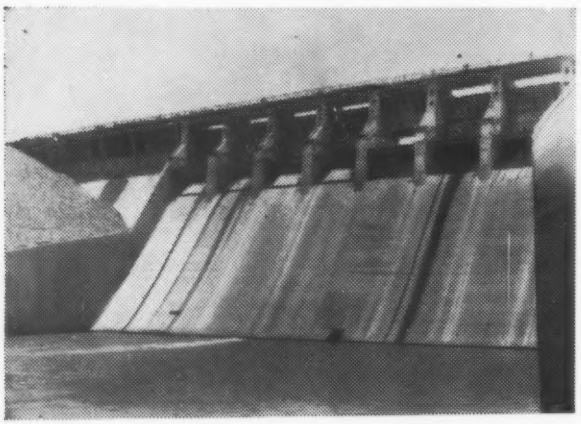

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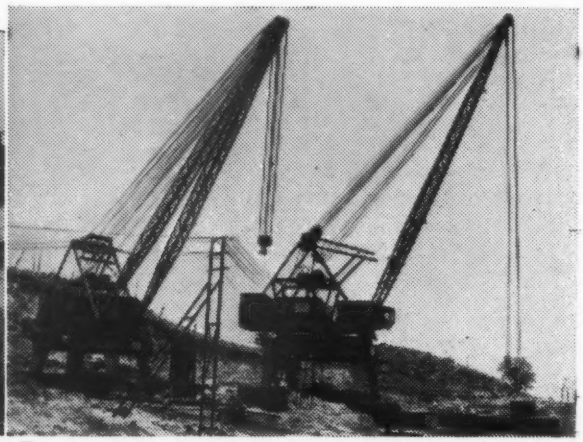

KAMPNAGEL Two—40 Tons full revolving cranes at MAITHON DAM.

The Benefits of the Damodar Valley Project

A. B. GANGULI

The author of this contribution was the administrator of the Mayurakshi Project in West Bengal before joining the DVC as a member. His work in the earlier assignment was marked by ability and great administrative competence. In this article he brilliantly summarises the benefits that will accrue to the people of the area due to the operation of the Damodar Valley Projects, thus underlining the conclusion once again that the Project has been well concieved. In this connection he has ably approached the criticism recently expressed in some quarters that the irrigation facilities offered by the Damodar Valley Projects are really superfluous in most parts of West Bengal. Recent studies have established the fact that perennial irrigation will revolutionise agriculture if proper agronomic practices are adopted.

Similarly in the field of power the earlier criticisms and hesitations are melting away and demand is racing fast with generation capacity. It is also worth noting that power to be supplied by the DVC will be priced as low as .75 anna per kWh, thus assuring the possibility of low rates to the small consumer.

DVC is a pioneer in the field of soil conservation efforts. It is heartening to know that this and other basic efforts are being pursued with great enthusiasm as the construction phase is coming to a close.

AUTHOR

Every year thousands of persons visit the various work-sites of the Damodar Valley Project. Most of them come for sight-seeing—to admire the magnificence of the Bokaro Thermal Power Station in its setting of emerald hills, to enjoy the placid expanse of the Konar and Tilaiya reservoirs, and to wonder at the mighty combination of men and machinery at work on the Maithon and Panchet Dams and the Durgapur Barrage. But the more discerning visitor, while impressed by the progress achieved and the herculean activities now going on, enquire what benefits will the people derive from the Project. This is a very pertinent question, and an attempt will be made in this article to deal with it without going into too much detail.

Multi-purpose Project

The Damodar Valley Project started as a flood-protection scheme. But Mr. Voorduin, the original planner of the scheme, advised the Government of India to make it multi-purpose by providing for irrigation and generation of power as well, so that the waters of the upper Damodar Catchment might be utilised to better advantage and the schemes might be economically viable. Though flood control was an urgent necessity, it is not directly productive of revenue and has to be regarded as an insurance measure. It was felt that by combining irrigation and generation of power, there would be substantial revenue. Also the Project will lead to rapid economic development of the entire Damodar Valley.

Flood Control

Though the Damodar is a small river its peak flood discharge is quite out of proportion to its size. Inspite of attempts at controlling the river by embankments there have been disastrous floods from time to time. A very fertile area has been under constant threat. Also, Calcutta's communication links with Northern India—the Eastern Railway and the Grand Trunk Road—have been in jeopardy time and again. Even the portion of the Calcutta industrial area lying to the west of the Hooghly was gradually coming within the danger zone. The Damodar Valley Project is designed to give protection against the highest recorded flood. The storage in Maithon and Panchet dams will largely be utilised for moderating the floods. But already the Tilaiya and Konar Dams, which have been completed are having some beneficial influence. The Maithon Dam, though still incomplete, will also retard the floods to some extent this year. The full immunity will be attained by 1958 on completion of the Maithon and Panchet Dams. The benefits of flood control are no doubt largely protective, but will be substantial and will be reaped mostly by the peasantry.

Irrigation

The Project will give Kharif irrigation to 10 lakh acres in the districts of Burdwan and Hooghly in West Bengal. Out of this area 3 lakh acres will also get rabi irrigation and grow more than one crop. A portion of the commanded area, nearly 1.8 lakh acres, is at present served by a canal system fed from a weir across the Damodar. The irrigation in this area is not so satisfactory as there is no storage which can guarantee supply in periods of shortage. This area will now get assured irrigation. Irrigation will commence from the Durgapur Barrage in the current year though the supply will be over a restricted area. There will be progressive increase in the irrigation acreage in 1956 and 1957. By 1958 the entire commanded area will be covered. Some storage has also been reserved for irrigation in the Upper Damodar Valley which is situated in Bihar. Owing to the undulating nature of the Upper Valley, irrigation schemes direct from the reservoirs are somewhat expensive and some schemes which had been investigated in the past had to be turned down on account

A. B. Ganguli, I.C.S., *is Member, Damodar Valley Corporation*

of the high cost. But investigation is proceeding and one scheme for irrigating 17000 acres seems attractive enough. The Corporation is anxious to devise schemes for irrigation in Bihar.

Though the value of irrigation is more or less well accepted, a doubt has been expressed in some influential quarters that irrigation is not so necessary in West Bengal and the Corporation will not be able to sell the water at a remunerative rate. This impression is based primarily on the refusal of the peasantry to take water from the Mayurakshi Canal system in the years 1952 and 1953. It has to be admitted that in the past irrigation schemes in West Bengal were largely considered protective. The monsoon is generally favourable and ordinarily the cultivators are in a position to grow a kharif crop without the aid of irrigation. But the recent studies clearly prove that irrigation can revolutionise agriculture. Once supply of adequate water is assured, better agronomic practices can be introduced and production can be greatly stepped up by the use of fertilizers and improved seeds. The average yield of paddy per acre in the lower Damodar basin is 19 maunds. This can be more than doubled by improved agricultural practices based on irrigation. It has been estimated on a conservative basis that the extra yield of paddy from the irrigated areas in the new Damodar system will be 10 maunds or more per acre. With proper use of fertilizers and better seeds, the yield will be substantially higher. But we should not confine our calculations to the cultivation of paddy alone. To get full value out of the irrigation there must be a more diversified cropping pattern. A large acreage should be turned over to sugar cane, potato, oil seeds, wheat and vegetables, enabling the peasantry to get much higher return and a more substantial diet. It is not unlikely that growing of fodder will also be considered more remunerative in some areas.

The Corporation is alive to the need of improving agricultural practices in the irrigated zone. Development of agriculture is, of course, the responsibility of the State Government. But the Corporation is anxious to play an active role in this sphere so that the benefits may reach the people sufficiently early. It has taken over an area of over 200 acres near Panagarh for an experimental farm. Here the latest ideas for improvement will be carefully tried out by a band of experts. The results will then be shown to the cultivators in a number of demonstration farms, in collaboration with the State Government. It is hoped that within a decade the pattern of agriculture will be substantially changed and the economic condition of the peasantry will vastly improve.

Power

At present the Corporation is supplying power from the Bokaro Thermal Power Station which has three sets capable of producing 50,000 kW each, and there is only a small hydro-electric station at Tilaiya with a capacity of 4,000 kW. Some critics have often questioned the necessity of a thermal power station in the Damodar Valley Project and have expressed the opinion that the Project should have been confined to hydro-electricity only. This criticism loses sight of the fact that there is a tremendous demand for power in the Damodar Valley itself and the adjacent industrial areas of Calcutta and Jamshedpur and the most satisfactory and economical way of meeting this need is to have an integrated system of hydro and thermal power. The water resources of the Valley are not large enough to meet even the present need for power. Also, all the available waters cannot be utilised without submerging large inhabited areas and without affecting many valuable mineral deposits. Another important consideration is that the present demand for power is only a fraction of the potential demand of this area. The abundance of coal and other valuable minerals, the proximity to the port of Calcutta, the existing communication facilities and similar favourable factors are likely to lead to rapid industrialisation of the area creating a tremendous demand for power. This demand can be best met by building a grid based on optimum use of available hydro power, largely supplemented by thermal power. It would have been a very short-sighted policy to utilise hydro power for supplying some local demands only and to leave the larger requirements of the area to be met by an independent system based on thermal power only.

When the First Phase of the Damodar Valley Project is completed, the Corporation will have a total capacity of 1.04 lakh kW of hydro power and 1.72 lakh kW of thermal power. After making allowance for stand-by, the firm system capacity is rated at 1.97 lakh kW. According to the load forecasts worked out by competent experts this capacity will prove inadequate by 1959-60. Further provision has been arranged for a 50,000 kW thermal set at Bokaro and a 40,000 kW hydro set at Konar. If the proposed steel plant is located in the Damodar Valley, as it seems likely, the capacity will have to be still increased.

Under the D.V.C. Act the Corporation can sell electrical energy only where the energy is taken by the consumer at a pressure of 30,000 Volts or more. It can therefore deal with the bigger industrial undertakings or authorities holding licences for local distribution. Over a large area in Bihar and West Bengal the State Governments are now themselves acting as the distributors purchasing power in bulk from the D.V.C. A question is often asked whether the DVC power is going to benefit the common man. It should be appreciated that the Corporation is debarred under the Act from dealing with the small consumer. It has to supply power in bulk to parties, who add on their own costs for retail distribution and charge their own tariff. The rate at which these distributors will purchase power from the DVC will seldom exceed .75 of an anna per kW hour and they should be able to keep their rates of supply reasonably low.

Apart from supplying power in bulk, the Corpo-

(*Continued on page* 29)

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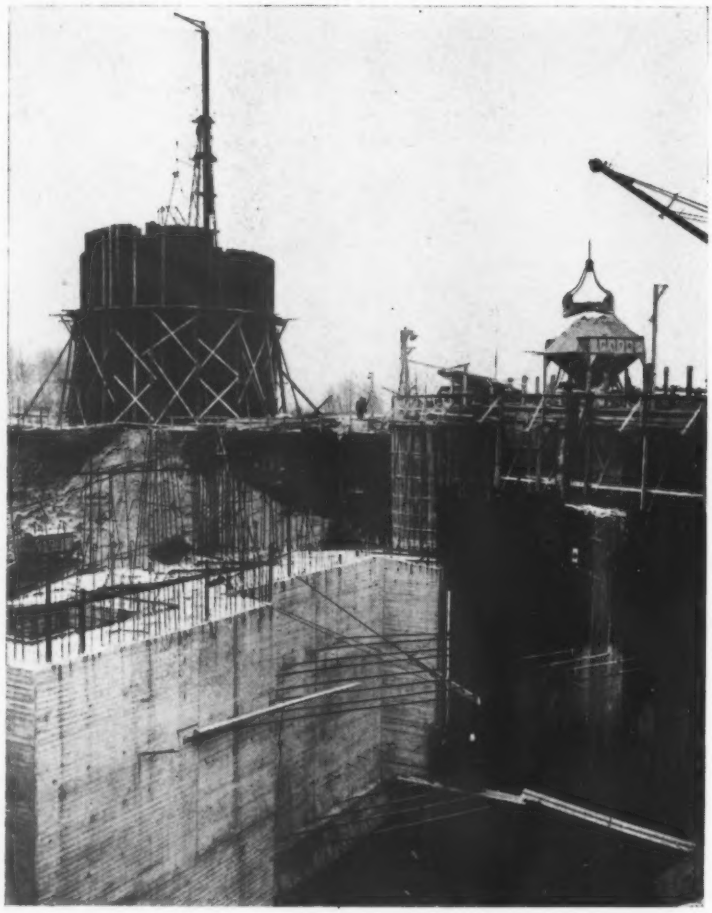

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Construction of Maithon and Panchet Hill Projects

A. M. KOMORA

It is one thing to plan and design a project and it is quite another to execute the same. The problem is to relate the design on blueprint with the available men and machines and the interwoven relationship between them. Mr. Komora with his wide experience has deftly planned the construction of the Maithon and Panchet Hill Dams in the Damodar Valley which are now under way. The various factors and situations, such as Geology, Climate and Hydrology, Operating Personnel, Time Schedule, and Phasing of Construction, need to be carefully assessed in the context of the job at hand before planning the construction. The following very instructive contribution by him will, we are sure, be read with great interest by our engineers who will have to carry on their shoulders the future task of executing valley projects for many years to come in the country without the aid of foreign experts. The basic idea involved seems to be that those who are incharge of construction should have a very clear idea of the dynamics of such activities and should be able to apply their imaginative intelligence with reference to the specific job in the context of given limitations and opportunities.

AUTHOR

Maithon and Panchet Hill are the last two dams being constructed by the Damodar Valley Corporation in the first phase development of the overall scheme. Maithon is located on the Barakar River just ahead of its confluence with the Damodar. Panchet Hill Dam is located on the Damodar River. Both dams are intended, primarily, for flood control with irrigation and power being secondary considerations. In the integrated scheme of the Damodar Valley the construction of Tilaiya, Konar (already completed), Maithon and Panchet Hill will reduce the peaks of all past floods on record to the bankfull stage of the Damodar River at Rhondia to a value not exceeding 250,000 cusecs. The completion of the four dams will not, however, control the design flood of 1,000,000 cusecs. To do this will require the construction of the balance of the dams as envisaged in the original DVC programme.

As designed, both Maithon and Panchet Hill are quite similar, viz., they are both primarily earthen structures with concrete gravity spillways. Maithon is situated on a straight stretch of river with relatively high hills on the left bank. The bed rock in the river channel is approximately 70 feet below the river bed, the overburden being a fine sand. Various schemes were proposed in the past for constructing a dam at this site. The design as finally worked out by the Harza Engineering Company worked out to be the most economical. Briefly, it consisted of a diversion on the left bank, an earthdam in the main river channel, a diversion channel on the right bank in which would be constructed a concrete spillway dam, and an underground power station on the left bank.

The original plan for Panchet also called for the construction of a dam on a straight stretch of river. Subsequent geological investigations indicated the advisability of selecting another site. The late Mr. L. F. Harza proposed a location one mile upstream on a 90 degree bend in the river. By excavating a diversion channel across the corner of the bend on the left bank it would be possible to construct an earth dam part way across the Damodar River and allow the first monsoon flow to sweep by the partially constructed earth embankment and through the partially excavated diversion channel. This sequence of construction procedure obviated the need for expensive cofferdams. The theory was well proven in the 1953 monsoon when the partially constructed earth dam in the Damodar River channel remained intact.

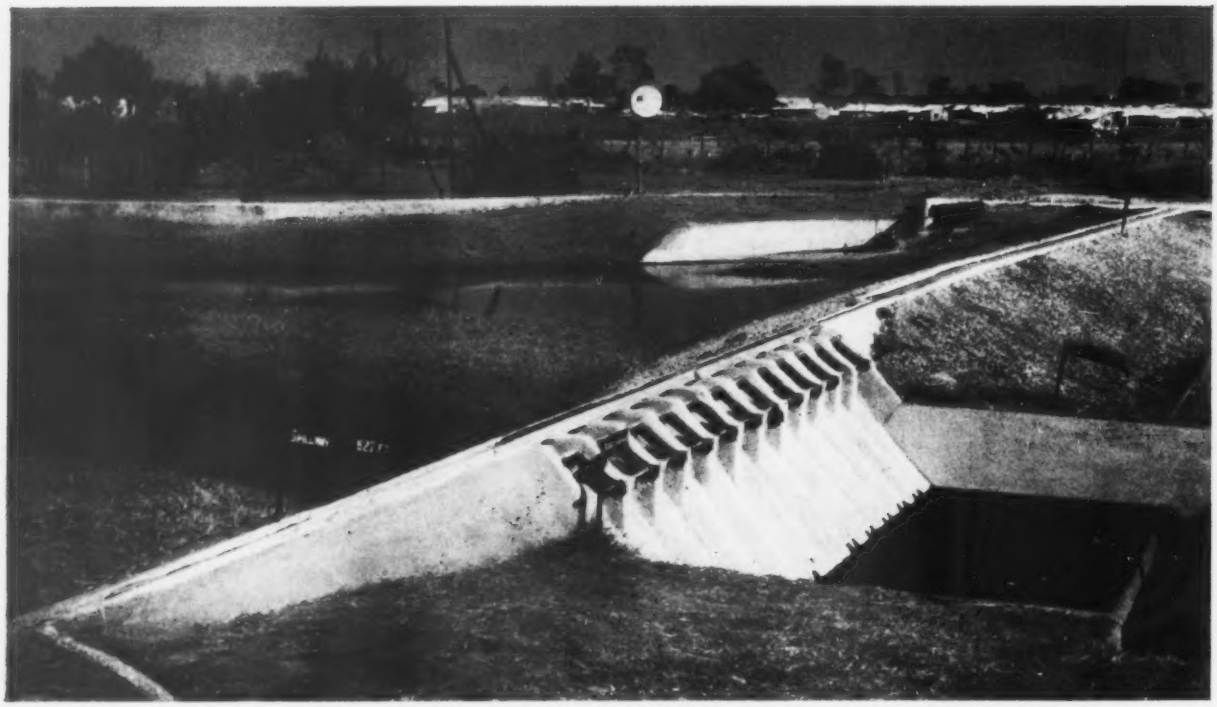
It has since been decided not to close the balance of the river gap in the 1954-55 working season but to complete all earthen dykes and to complete the foundations of the concrete dam in the diversion channel. The river gap can be safely closed in the 1955-56 working season simultaneously with the completion of the concrete dam.

Having decided on the types of structures and the sequence of construction of each project, viz., Maithon and Panchet Hill, it was then necessary to select the construction plant to do the job. The selection of a plant depends on many factors, namely:

(1) *Geology*. The type of materials to be excavated, placed and compacted.
(2) *Climate and Hydrology*. The maximum variations in daily temperatures, the frequency of daily and seasonal rainfall and the resultant river run-off.
(3) *Operating Personnel*. Whether the necessary operating personnel is available for operating the construction equipment.
(4) *Time schedules*. The length of time in which it is desired to construct the projects.
(5) *Phasing of Construction*. The phasing of construction of more than one project.

The proper and improper selection of construction equipment can make or break a job. The selection, to a great extent, is based on past experience taking

A. M. Komora *is Chief Engineer, Damodar Valley Corporation.*



Model of Maithon Dam.

Earth Dam, Maithon.

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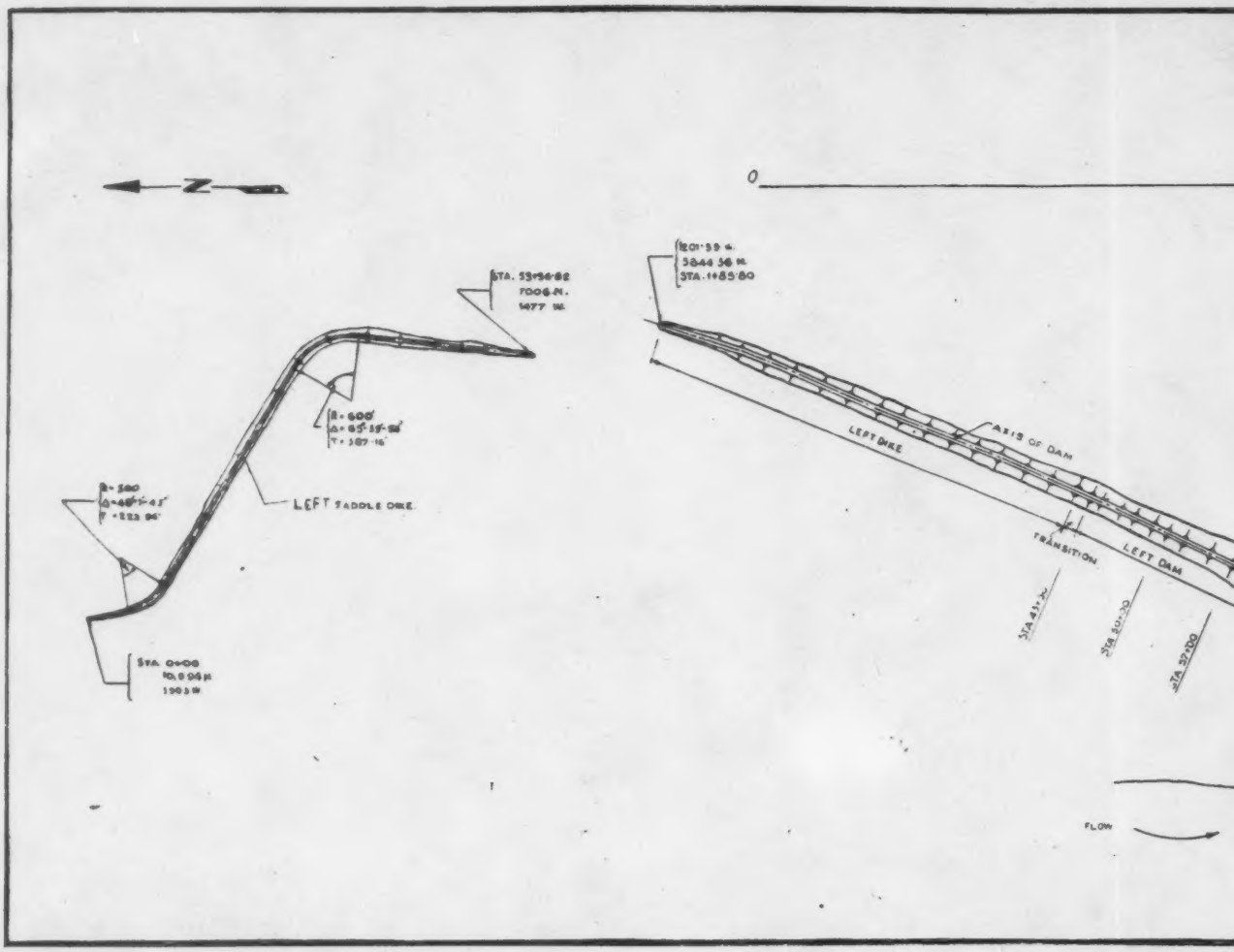
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1006 M.
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R = 600'
Δ = 65°-35'-00"
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LEFT SADDLE DIKE
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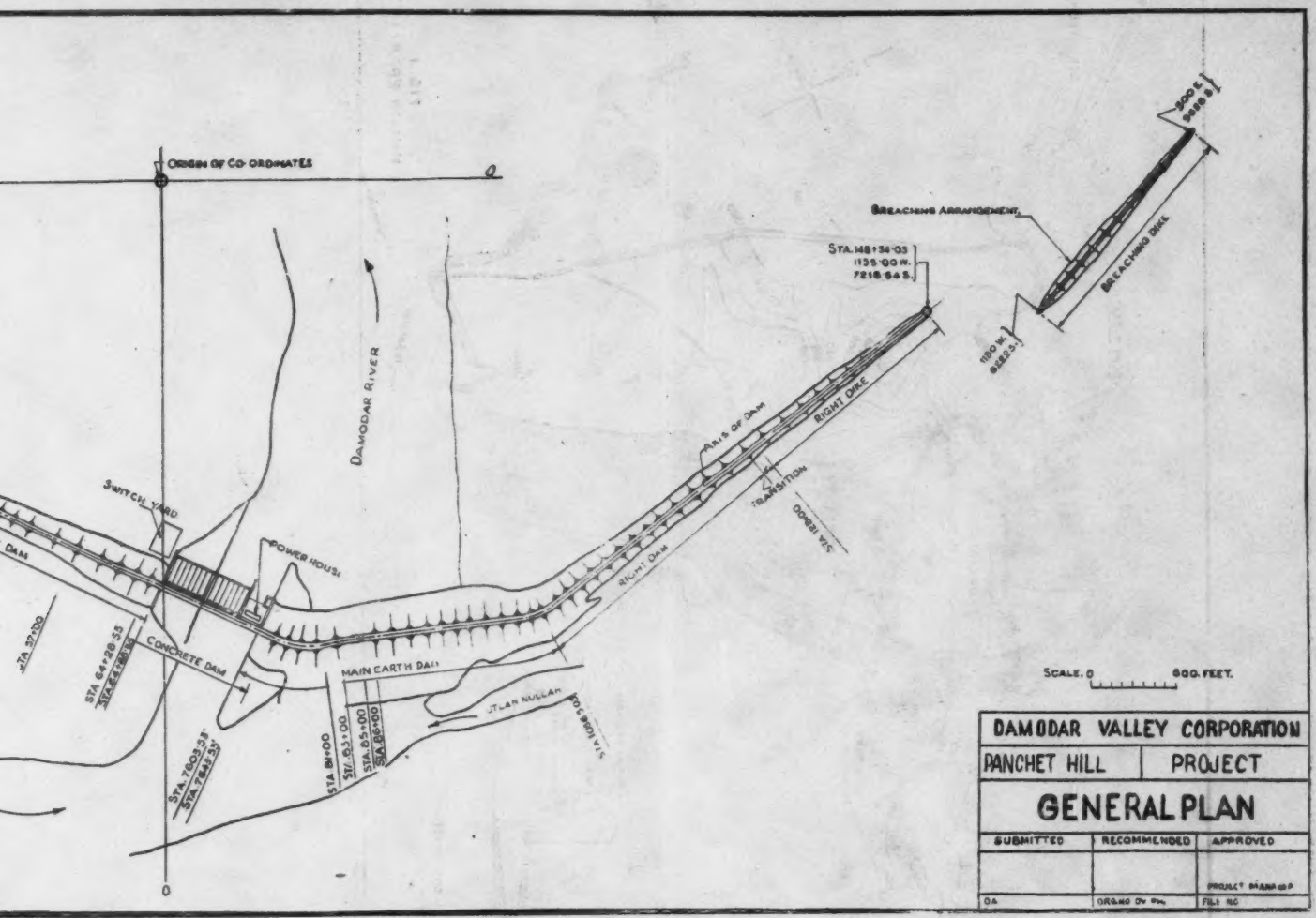

DAMODAR VALLEY CORPORATION	
PANCHET HILL	PROJECT
GENERAL PLAN	
SUBMITTED	RECOMMENDED / APPROVED
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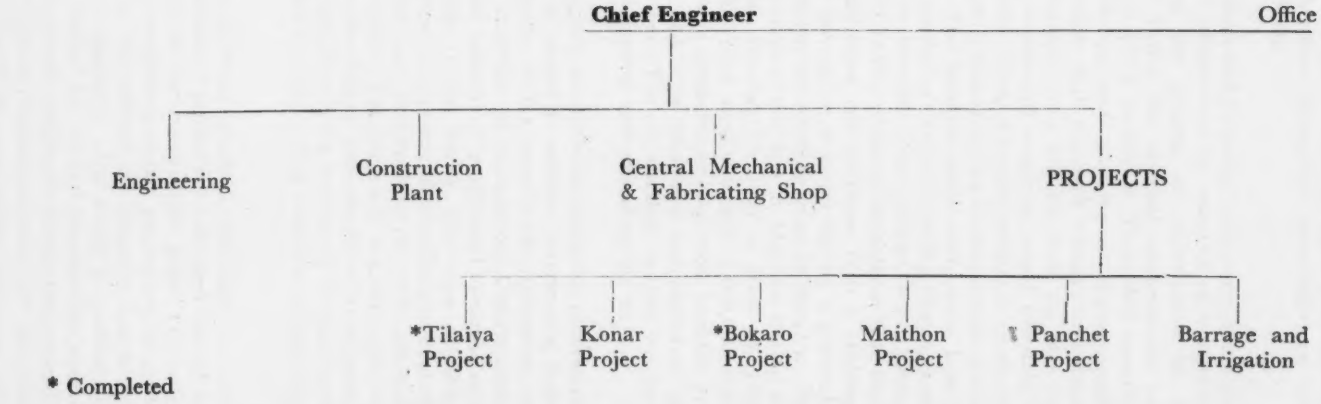
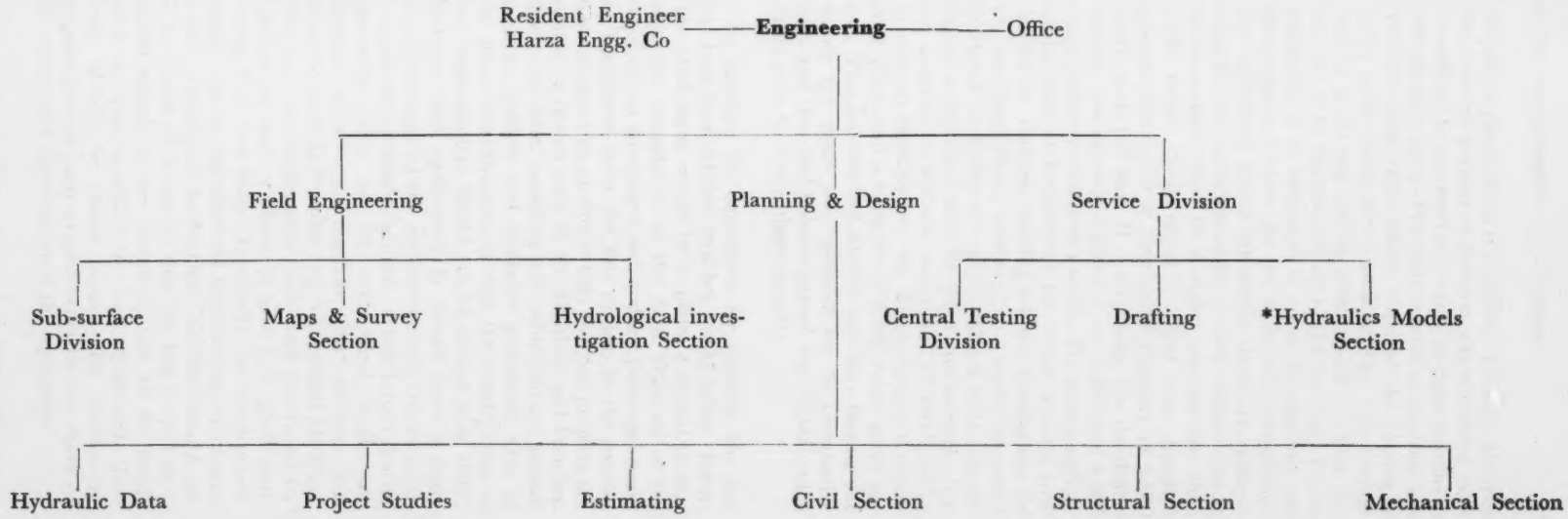
DVC Organisation Chart

March 1955





* Under the Director of River Research Institute, West Bengal.

into account the above criteria. Had Maithon been considered alone then possibly larger capacity excavators and hauling units would have been selected for this job. The diversion channel area was interspersed with large boulders which would have reduced the need for a great deal of secondary blasting. The DVC had already in existence a large number of medium-sized excavators of $2\frac{1}{2}$ cubic yard capacity and hauling units of 10 to 15 cubic yard capacity. It was therefore decided to standardize on these capacity units.

The climate and hydrology of a given region have a decided influence on the selection of construction plant and the phasing of construction. In the Damodar Valley the seasonal temperatures vary from about 40° F to 120° F. Three-shift operation was tried during the first three years of construction. The extremely high day-time temperatures during April, May and June are too hard on men and machine. A two-shift operation would probably be more in order. This, of course, pertains to earthwork. On concreting operations work can continue around the clock. The monsoon which starts about June 15 and ends the first of October is both a blessing and a challenge to the construction planner. It is a blessing in that it is known within quite definite time limits when construction can continue. It is a challenge that once having set a target during a particular working season the schedule must be attained. The best illustration of this was at Maithon during the period from October 15, 1952 to June 15, 1953. During this time approximately 2,000,000 cubic yards of earth, semi-decomposed rock, boulders and hard rock had to be excavated and placed on the main river bed. The job was done in time but there were many anxious moments along the way.

The adequacy, or otherwise, of capable experienced operating personnel is another determining factor on the selection of the construction equipment and the time schedule of completion. Unfortunately, the requisite numbers of experienced operators were not available in the Valley. The same condition probably prevailed in other parts of India as frequent "raids" were made and many of the DVC operators were lured away. The net result was that probably a few more machinery were employed than would have been necessary had a ready pool of experienced operators been at hand. This condition is improving rapidly.

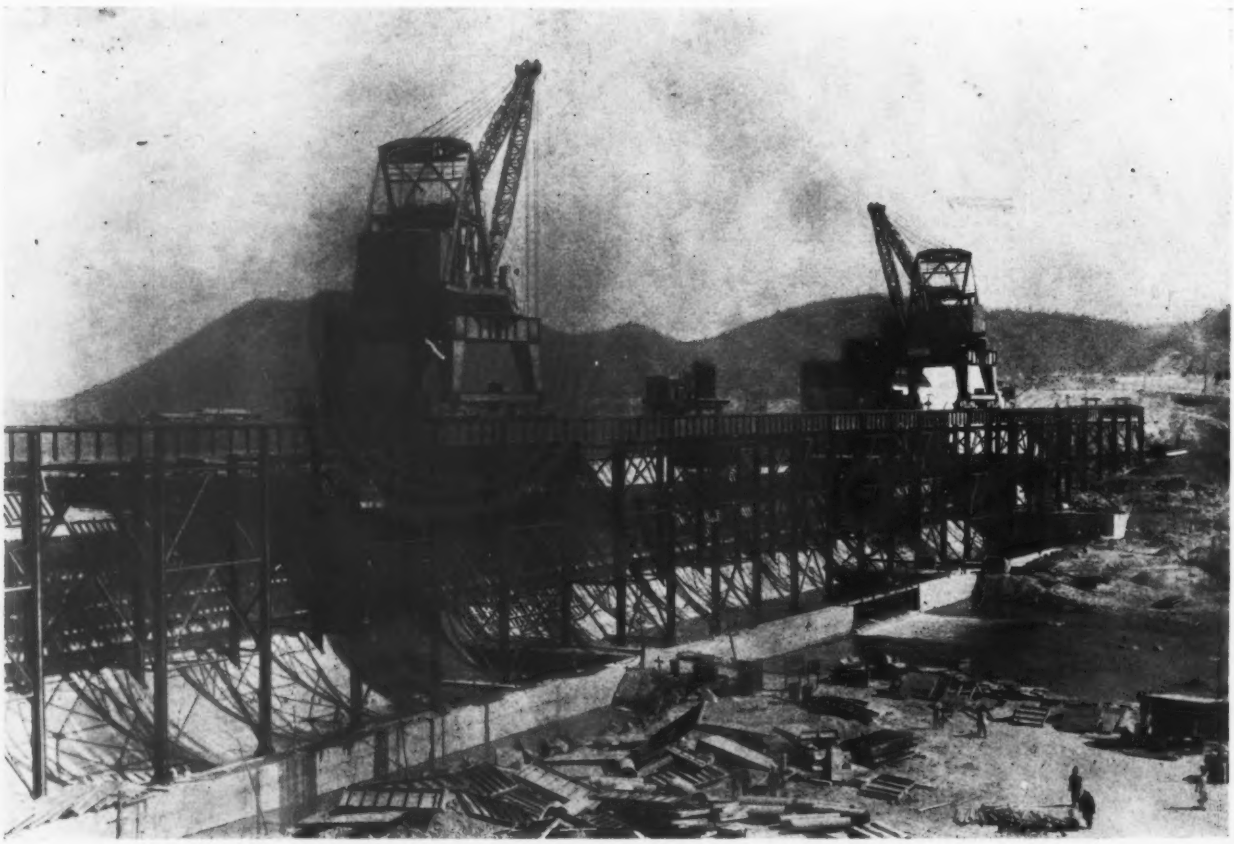
The time schedule which is established for completing a particular project has a decided bearing on the selection of the construction plant. Obviously the time to complete a certain project can be made so short that the cost of the requisite number of construction equipment units would be prohibitive. A balance should be reached between the overall return from an early completion and the total expenditure involved in the construction costs. On the other hand, time allowed for construction and completion of certain features of a project automatically dictates the size of plant which is required. Thus for Maithon the concrete portion of the dam was scheduled to be completed in one working season of eight months or 200 working days. The total volume of concrete was 450,000 cubic yards which required the placing of 2,250 cubic yards every working day. The average rate of 2,250 can not be attained on the first day nor can it be maintained up to the last day. In the beginning it is necessary to cover foundations and the progress is slow. As the dam nears completion the individual blocks are small, there are spillway piers etc. and progress again is slow. Somewhere in between there must be a higher placing rate than 2,250 cubic yards daily. A plant was therefore selected which has a theoretical capacity of 4,000 cubic yards per day. It is surprising but the difference in cost between a plant of say 2,500 and 4,000 cubic yards capacity is very small. The same auxiliary works such as foundations for crane trestles, steel trestles for concrete placing cranes, foundations for the batching plant, crushers, etc. would be about the same for either size plant. Also a factor of efficiency of operation must be taken into account. It is not possible to operate any plant at 100 % of its theoretical capacity. At the Norris Project the concrete plant had a capacity of 4,400 cubic yards per day. This was reached on only one day. During one month the plant was operated for 30 consecutive days and the total volume placed was 98,000 cubic yards or 74 % of the plant capacity.

In selecting the equipment for Maithon the fact was kept in mind that Panchet would follow closely. The ideal thing would be to phase a second project after the completion of the first. Thus all of the construction equipment and trained personnel could be transferred from the first project to the second. This is assuming of course that the two projects are similar in design such as are Maithon and Panchet. There are other considerations which do not permit such an orderly and desirable procedure. One of the main considerations is that the construction of any major project should not be started with 100% partially used equipment. It should have a fairly high percentage of new equipments and this especially applies to earthmoving units. A new large capacity concreting plant, on the other hand, might last through several projects. The final decision was made to schedule Panchet one year behind Maithon. Only such new equipment items were purchased for Panchet as were required to give it a good start during the first stage. Gradually as construction nears its end at Maithon the construction equipment is being transferred to Panchet. The fact should not be lost sight of, however, that the last project in a unified scheme is the "catch-all" for all the headaches in trying to utilize the used equipments. Just debits should be raised against the transferring projects so that each project bears its fair share of the repairs and depreciation of the equipment.

There is one thing which has been said many

(*Continued on page* 28)

Concrete dam under construction (upstream face), Maithon.



Concreting work on the diversion cut, Maithon.

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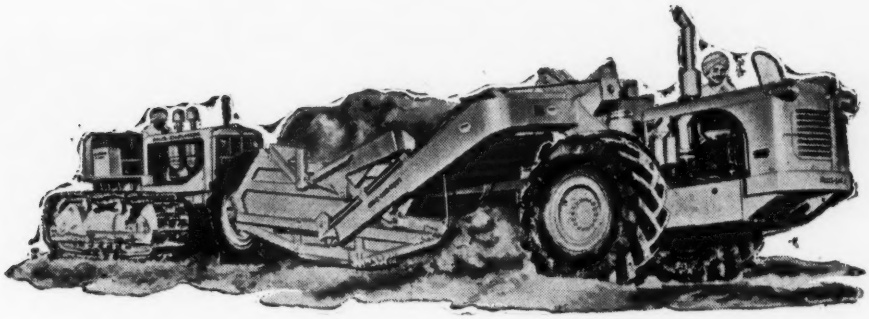

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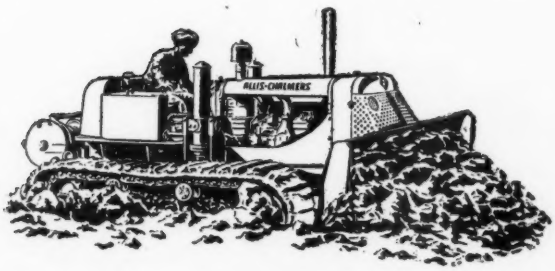

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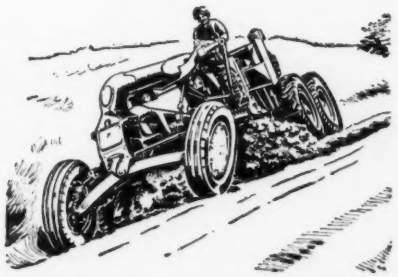

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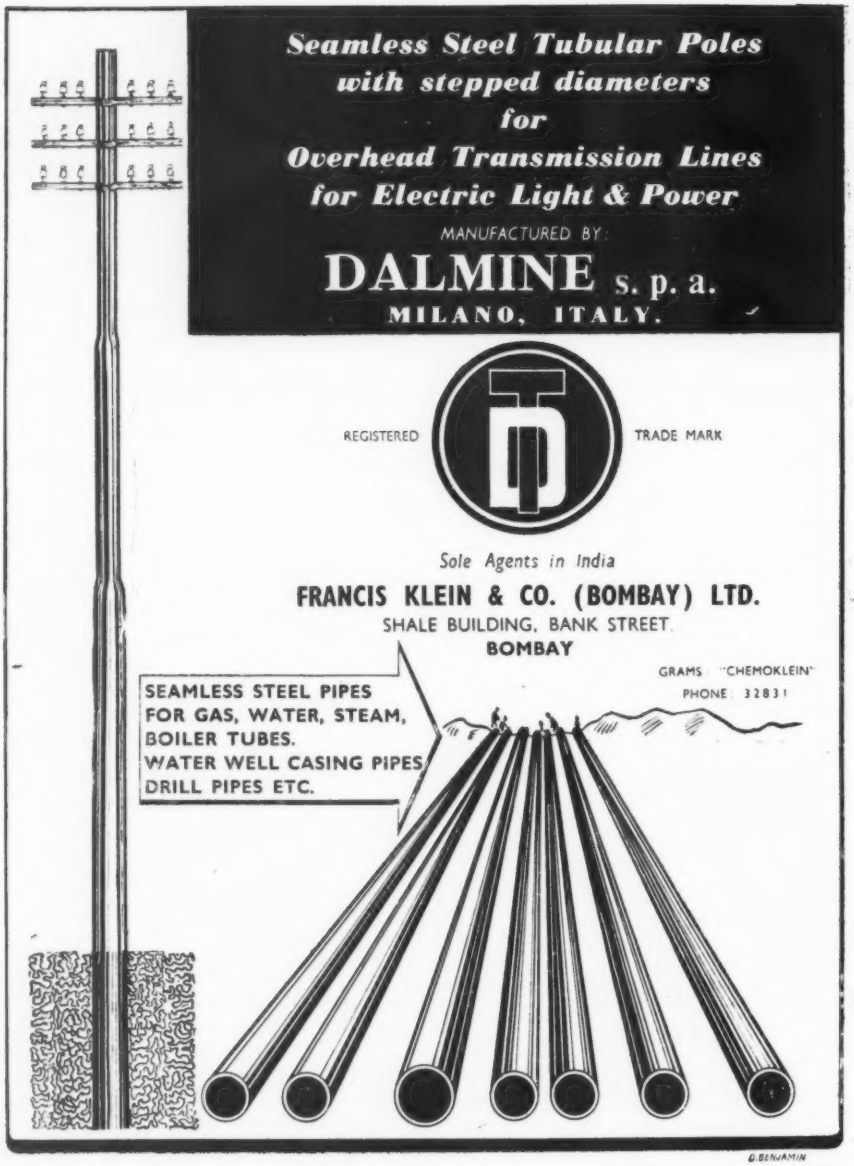
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Development of Thermal and Hydro Electricity in Damodar Valley

By

P. K. BHATTACHARYA

Chief Electrical Engineer, Damodar Valley Corporation

AUTHOR

The Damodar Valley which covers an area of approximately 8,000 square miles is unusually rich in natural resources. The valley and its adjacent areas contain specially rich and varied minerals such as iron ore of a very high quality, copper ore and bauxite, and in addition a large variety of other minerals. An iron and steel industry has grown up in this region. There are copper smelting and aluminium extraction plants. Practically all of India's coal production, and all its mica production come from mines in this area. Other industries include rod mills, chemical plants, lime and cement mills, stone quarries, ceramic, glass and refractory works, textile mills, locomotive manufacture and other engineering works. Although this area has advanced industrially more than any other part of the country, the present progress falls short of expectation for a region so richly endowed by nature. The main retarding factors have been the lack of a perennial supply of water for industries and the industrial population, and of an abundant supply of electric power.

The Damodar Valley Project, amongst other things, includes production and distribution of power on a large scale and the control of the flow of water in the Damodar and its tributaries. Once perennial water and plentiful power are assured, the full exploitation of the natural resource of the Valley will be accelerated.

Load Survey

An exhaustive load survey of the valley and adjacent areas was carried out and estimates were made of the existing and potential loads likely to develop in the next three quinquennial periods. The total installed electrical generating capacity is about 391,600 kW excluding the 80,000 kW plant erected at the Sindri Fertilizer Factory, made up as follows:

The installed capacity in 12 towns & villages	..	24,000 kW
The installed capacity in industries	..	269,300 kW
The installed capacity in 39 independent power stations and three major licensees	..	98,300 kW
		391,600 kW

The aggregate maximum demand on the existing generating stations is about 200,000 kW.

The old plant is being gradually replaced by supply from DVC, and only a portion of the existing plant will remain in service after sometime. For instance in the case of town installations surveyed, in all cases except one, the installed capacity has been found inadequate, conditions of plant unsatisfactory, and working uneconomical. Many of the colliery power stations are likely to close down gradually when adequate power from outside sources becomes available. The existing power stations of licensees in the colliery area, which are inadequate for the load awaiting to be served, are utilised to supplement bulk supplies from the DVC. The generating plant installed in the major industries, while in a fairly good condition, are not capable of coping with the increasing demand for power due to expansion of the industries.

Apart from electric generating stations, a large number of steam and oil engines are used for purposes other than generation of electricity. The aggregate installed capacity of steam and oil engines used for purposes other than generation of electricity is estimated 136,000 HP. As most of the steam engines are old and have run their useful lives, they are likely to be replaced by electric motors gradually as electric supply becomes available.

As a result of the load survey carried out by the Central Technical Power Board, the total prospective maximum demand on the DVC system was assessed at 282,000 kW, 459,000 kW and 550,000 kW during the next five, ten and fifteen years. While the region covered by the survey can be reasonably served when the Damodar Valley Project is fully implemented,

it may not be possible to reach all the loads disclosed by the report during the early phase of development. The prospective maximum demand in the area covered in the first stage is 106,000 kW, 274,000 kW and 333,000 kW at the end of five, ten and fifteen years respectively. This picture of course changes from time to time. This load is spread over a service area of some 35,000 square miles.

System Planning

The initial Power installations aggregating to 254,000 kW of installed capacity is made up of 150,000 kW of thermal plant at Bokaro and 100,000 kW of hydro installations distributed between the Maithon and Panchet Hill dams and 4,000 kW at the Tilaiya dam. The Bokaro Thermal station and the Tilaiya hydro power station were completed in 1953, and the hydro installations at Maithon and Panchet Hill are likely to be ready in 1956/57 and 1957/58. In order to meet the system demand, another 50,000 kW set for the Bokaro Thermal Power Station and a 40,000 kW hydro station at Konar have been proposed.

Bokaro Thermal Power Station

The Thermal Power Station at Bokaro is the most modern station in India to-day. Located on the River Konar, just below the confluence of the Konar and the Bokaro, it is designed for an ultimate capacity of 200,000 kW. Initially three 50,000 kW sets, with a total generating capacity of 150,000 kW have been installed.

The power station has been located close to the coal mine from which it will obtain its coal supply; there is easy access to the site both by road and rail. It is about 50 miles from Hazaribagh town and 233 miles from Calcutta by road.

The Konar river supplies all the water necessary for the power station. A dam on this river which has been built about 12 miles upstream will besides its other utilities, will ensure a constant water supply of 400 cusecs to the plant. In addition to the dam, a solid concrete barrage has been constructed across the river at the plant site to provide sufficient site storage.

The station has been designed for base load operation for about 37 weeks of the off-monsoon period, and as a peak load station for the remaining 15 weeks in the monsoon. The latter perod of light load will afford opportunity for general overhaul and inspection of machinery.

Coal Supply and Coal Handling Plant

The boilers at the power station are designed to use inferior-grade coal having an ash content of 26 to 30 per cent. The coal is obtained by open cut mining of the Bermo seam at Kargali, about 5 miles from the power station.

The coal mine belongs to Messrs. Bokaro & Ramgarh Ltd., and is under lease to the G.I.P. Railway. It has now been sub-leased to DVC for a period of 35 years. It is estimated that the present leased area contains about 17 million tons of coal of the following proximate analysis:

Moisture	..	0.7%
Volatile Matter	..	23.4%
Fixed Carbon	..	46.3%
Ash	..	29.6%
Calorific Value (dry basis)	..	10,200 BTU
Fusion Point of Ash	..	2,386°F

The coal mining is at present partially mechanised, the overburden is removed partly by manual labour and partly by machine, the coal is raised by manual labour. In the course of the next two years, it may be possible to fully mechanise the mine. The loading of coal into the buckets at the mine and its discharge into the 200-ton bunker at the power house is done automatically. In case of emergency, resort may be taken to rail transport from the mine to the power station.

The coal from the ropeway bunker, or rail track hoppers is fed, by means of reciprocating feeders, into either one of the duplicate conveyors. After passing over a magnetic pulley, it is fed into a crusher capable of reducing the run of mine coal to $\frac{3}{4}''$. From here it is either conveyed to the station bunker on the top of the boilers or to stockpile in the yard. The storage yard will be a sector of about 160°, having a radius of 350'. A drag scraper piles the coal to a maximum height of 26 ft. and also packs it to eliminate spontaneous combustion and losses through carrying away of fines. The coal yard holds a stock to last $2\frac{1}{2}$ months. A reverse drag bucket reclaims the coal from the stock-pile when necessary. It is dumped into the reclaim hoppers and fed back into the conveyor system.

For each generating set there are two boilers, and each boiler is fed by two coal bunkers. To prevent jamming at the bunker gates, paddle arch breakers are installed. From each bunker the coal is dropped through an automatic weighing scale and fed into a bowl mill. A variable-speed automatic feeder governs the supply of coal to the mill to suit the load. The bowl mill is designed to pulverize coal, having a grindability of 55 Hardgrove and a maximum moisture of 10%, to a fineness of 80% through 200 mesh. Coal is dried by means of primary air from the air preheater passing through the mill. Provision has been made for automatically rejecting tramp iron or any other hard foreign matter. The fineness of the pulverized coal is controlled by air separation. The pulverized-coal-laden air is carried to four horizontal burners located in the furnace front wall. They have air mixing chambers and adjustable air dampers for control of hot secondary air from the wind box. Each boiler is provided with two pulverizers, each capable of handling 24,000 lbs/hour of coal, equivalent of producing 1,95,000 pph steam.

A pump house is erected at the railway siding, housing two 150 gpm lighting oil transfer pumps. These pumps transfer oil from tank wagons or trucks to two—30 feet dia. storage tanks. Lighting oil be fed by gravity to two—600 gpm pumps located in the basement floor. Each boiler is fired by this oil through four burners equipped with mechanical automizing oil gun.

Steam Generating Units

All the six steam generating units are alike, and were supplied by the Combustion Engineering and Superheater Inc. of New York. These units are of the two-drum radiant type, rated at 300,000 pph, 900 psi, 910°F, with an initial feed temperature of 415°F. Owing to this high temperature of feed water, it is not necessary to have an economizer in the boilers. The furnaces are water-cooled, with a volume of 21,625 cft. each, and are of the dry-hopper-bottom type. Each unit incorporates a two-stage-pendant type superheater and a 74,800 sq. ft. three-layer regenerative type of air preheater.

In order to ensure freedom from slagging, the furnace is designed for a low heat release of 17,000 Btu/cft/hour. For the same reason, the gas temperature entering the first boiler tube bank is about 2,100° F, well below the ash-fusion temperature.

Because of the high steam temperature, the secondary superheater elements are of chrome-moly-titanium: 40% of the primary superheater tubes are made of carbon-moly steel and the remaining of low carbon.

The steam drum is 60″ in diameter, and 31′-1″ long with tube steel plate 4-1/16″ thick and top sheet plate 2-5/8″ thick. The drum is fusion-welded from steel plate with the tensile strength of 70,000 psi. All seams have been checked by radiograph.

Dust Collection and Ash Disposal

The dust-collecting system, of Western Precipitation design, consisting of multiclones, is located between the air preheater and the induced draught fan to minimise erosion of the fan blades.

The bottom ash, that is ash accumulated in the furnace hopper of each boiler is removed automatically. Oscillating feed nozzles move the ash from each hopper to the sluiceway, along which the ash is conveyed by transport nozzles to the clinker grinder. Three vertical 800 gpm 150 psi. ash water pumps are provided. Two of these are in operation and one is spare. Two-4000 gpm ash pumps are installed, either of which can handle the combined ash and ash removal water for the system. These pumps will transfer ash and water from the ashpit to the ash disposal well located outside the power station.

The fly ash for the boiler pass, air preheater, duct, collector and stack hopper is removed by means of vacuum system. This consists of hydraulic ejector for each set of two boilers. The dust is removed with the water steam and discharged to the sluice way.

Turbo-Generators

Each of the three turbo-generators generates 50,000 kW at 0.85 power factor, 13.8 kV, 50 cycles, 3,000 rpm with hydrogen cooling. The turbine is rated at 850 lbs, 900°F 1.7 Hg, with five stages of extraction. By increasing the hydrogen pressure from ½ lb. to 15 lbs. per sq. inch, the maximum continuous output of the generator can be increased to 57,500 kW at 0.85 Pf.

The turbine is single-cylinder type with one Curtis and 19 impulse stages. Steam is bled from the turbine at five stages for feed water heating and deaeration. This amounts to 28 per cent of the steam passing through the main steam valve.

The safety devices incorporated with the turbine consists of an emergency overspeed governor and low vacuum trips, combined with low steam pressure load limit for quick starting of the machine. The turbine supervisory instruments consisting of an eccentricity recorder, a differential expansion recorder and a speed and cam shaft position recorder are also provided.

Special oil seals minimise the leakage of hydrogen. This is estimated at 200 cft. per day, and is automatically replenished from the hydrogen cylinders installed near the generator. At the time of filling and evacuation, the generator is scavenged by CO_2 to eliminate fire hazard.

The condensers are of Foster Wheeler make, and of the double-pass cross-flow design with an effective cooling surface of 47,500 sq. ft., and are provided with air cooling zone. A hot well is furnished having a storage capacity of 1 minute flow. For removing the condensate from the condenser, a horizontal type two-stage centrifugal pump has been provided, capable of handling 1,000 gallons of water per minute at a total head of 210 ft.

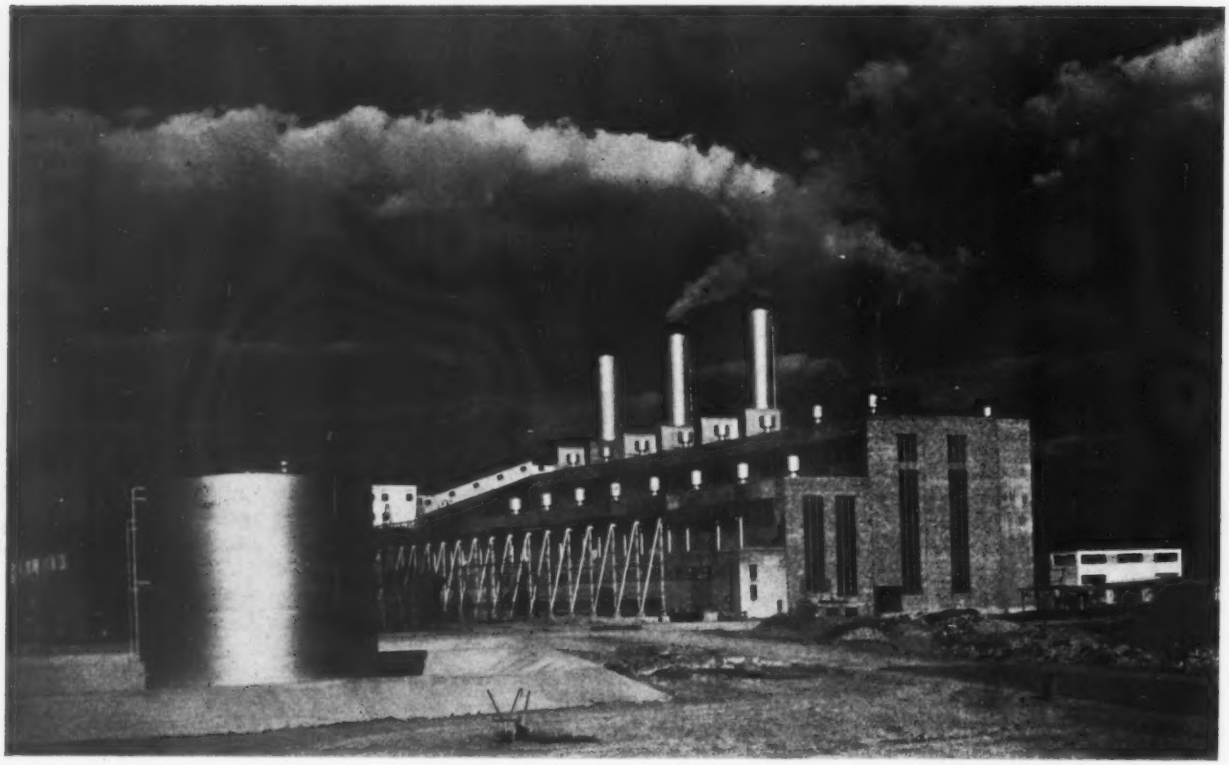
For removing air and non-condensable gases from the condenser, one main ejector comprising a two-stage twin element unit has been furnished, each element having a capacity of 11.5 CFM dry air and steam consumption of 690 lbs per hour.

The ejector is complete with a surface inter and after condenser. The oxygen content of the condensate, as discharged by the hot well pump, does not exceed 0.03 cc/litre. a hogging jet has been incorporated to reduce the initial time for producing vacuum.

The vertical mixed-flow water pumps supply 27,500 gallons of cooling water per hour each at 45 ft. head

Feed Water System

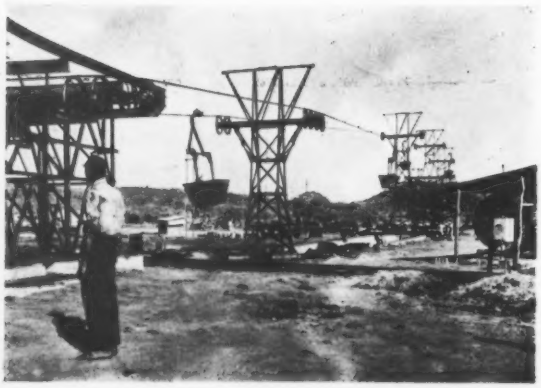
There are three feed pumps for each group of two



Top: Bokaro Powerhouse from south west corner.

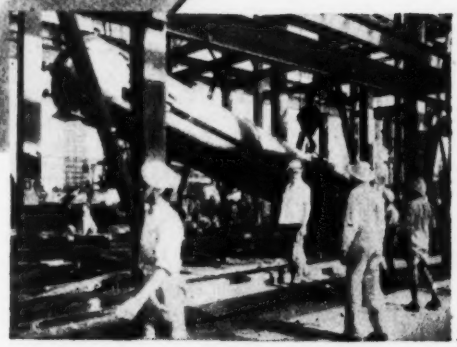
Right: 3 Generating sets at Bokaro inside the Power house.

Bottom: Ropeway at Bokaro.



Bokaro

Model of the Bokaro Plant.



Raising one of the 81,000-pound steam drums.

Symbol of Power Progress in the East

In India's Damodar Valley, the Bokaro Steam Power Plant has gone into production, bringing 180,000 kilowatts to this mineral-rich but power starved section of northern India. Bokaro is part of a government-financed project which includes also nine hydroelectric stations, aimed at industrial development, irrigation, and flood and erosion control.

Bokaro is owned and operated by the Damodar Valley Corp., and was designed by, and constructed under the supervision of, The Kuljian Corporation of Philadelphia. The largest steam plant ever built in Asia, it has in operation three 60,000-kw turbine-generators; a fourth is projected for the near future.

Each turbine-generator is powered by two boilers furnished by Combustion Engineering Inc. Nominal capacity of each steam generating unit is 300,000 pounds of steam per hour at 895 psi and 910 F. The boilers are fired by pulverized coal, conveyed two miles from Bermo Coal Fields, world's largest strip coal mine.

Bokaro highlights again the major role played by Combustion in helping furnish power to restore and expand the economies of free nations throughout the world. It is an example, too, of the world-wide scope of C-E activities—activities that range from Alaska to South Africa . . . Australia to Italy.

Bokaro proves that—wherever you are . . . whatever your steam requirements—Combustion stands ready to serve you with all that's latest and best in steam generating or fuel burning equipment. Get in touch with our Export Department in New York for prompt attention to your inquiries.

C-E

COMBUSTION

ENGINEERING INC.

200 Madison Avenue • New York 16, N. Y.

ALL TYPES OF STEAM GENERATING, FUEL BURNING AND RELATED EQUIPMENT

Agents in India—**J. STONE & CO. (India) LTD.,** CALCUTTA, BOMBAY, MADRAS, NEW DELHI.

'ENGLISH ELECTRIC' to build Britain's 200 MW largest steam turbo-generator

The CENTRAL ELECTRICITY AUTHORITY has awarded the Company the order for the first 200,000 kilowatt (270,000 h.p.) machine—twice the rating of the largest steam turbo-generator yet in use in Britain.

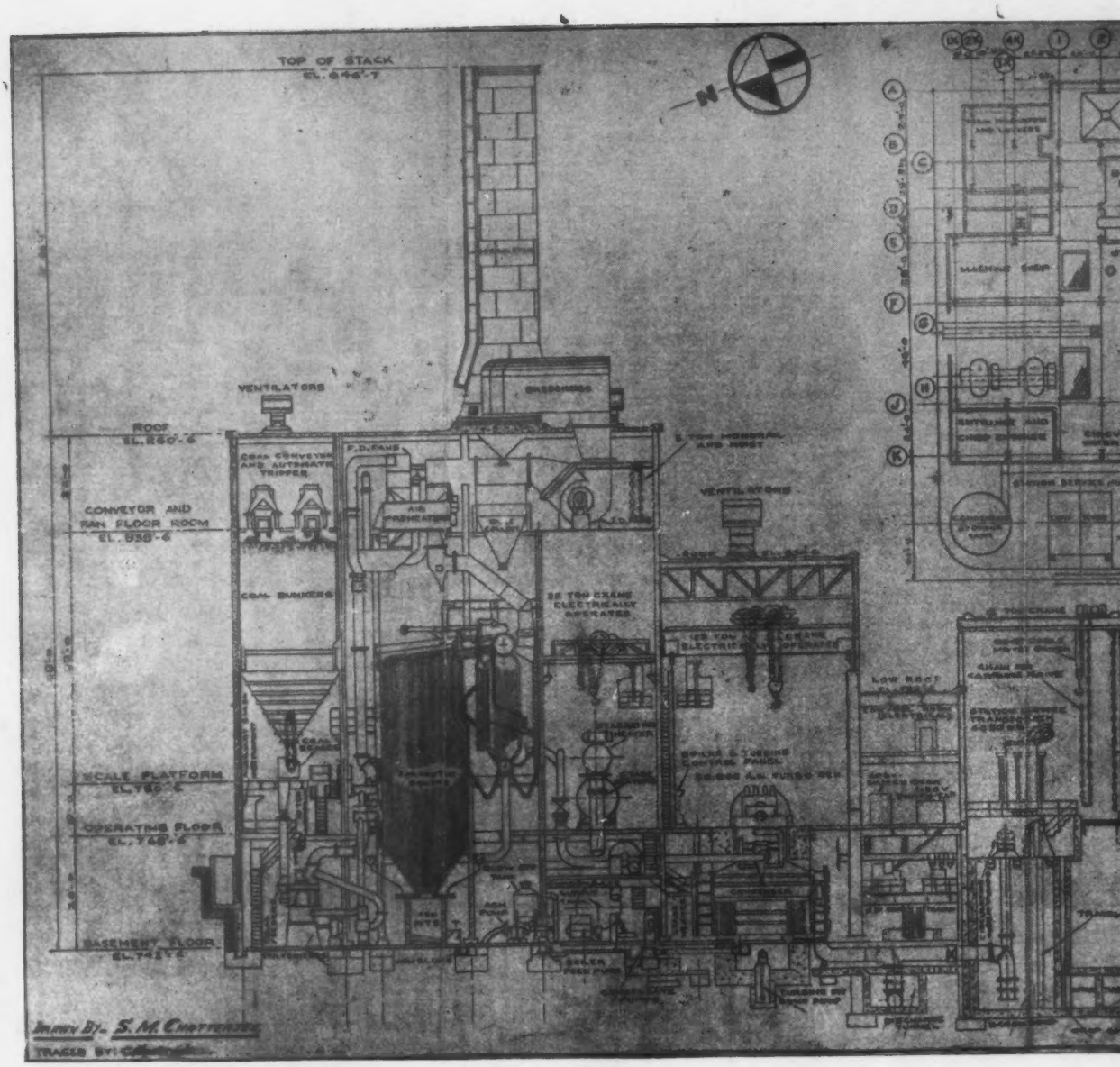
★ Won in direct competition, this order marks the first stage in the super power station which, subject to ministerial consent, will be built at High Marnham on the River Trent and is planned to add over one and a third million horsepower to the country's generating plant capacity. ★ Of some 270 C.E.A. power stations, only 24 produce more electricity than will come from this one machine alone! ★ This order is the outcome of the research, design and engineering resources which have already led to the installation of 'ENGLISH ELECTRIC' turbo-generators in so many up-to-date power stations throughout Britain and the World. To have secured it confirms once again the Company's international lead in the design and manufacture of large turbo-generators.

technical data

The turbine and alternator are directly coupled in line and run at 3000 r.p.m. and the unit comprises a 3-cylinder turbine operating at 2350 p.s.i.g. 1050°F. at the turbine stop valves, re-heating to 1000°F. at the intermediate pressure cylinder and exhausting to a single shell condenser operating at 28.7" vacuum with six stages of feed water heating to 460°F. The single alternator is of the direct hydrogen-cooled type generating at 16,500 volts and having a rated gas pressure of 30 p.s.i.g.

THE ENGLISH ELECTRIC COMPANY LIMITED. CALCUTTA BOMBAY MADRAS NEW DELHI LUCKNOW

EEX-23


TOP OF STACK
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VENTILATORS
ROOF
EL. 860'-6
CONVEYOR AND
FAN FLOOR ROOM
EL. 838'-6
SCALE PLATFORM
EL. 780'-6
OPERATING FLOOR
EL. 748'-6
BASEMENT FLOOR
EL. 742'-2
F.D. FANS
AIR PREHEATER
COAL BUNKERS
25 TON CRANE
ELECTRICALLY
OPERATED
DRAWN By: S. M. CHATTERJEE
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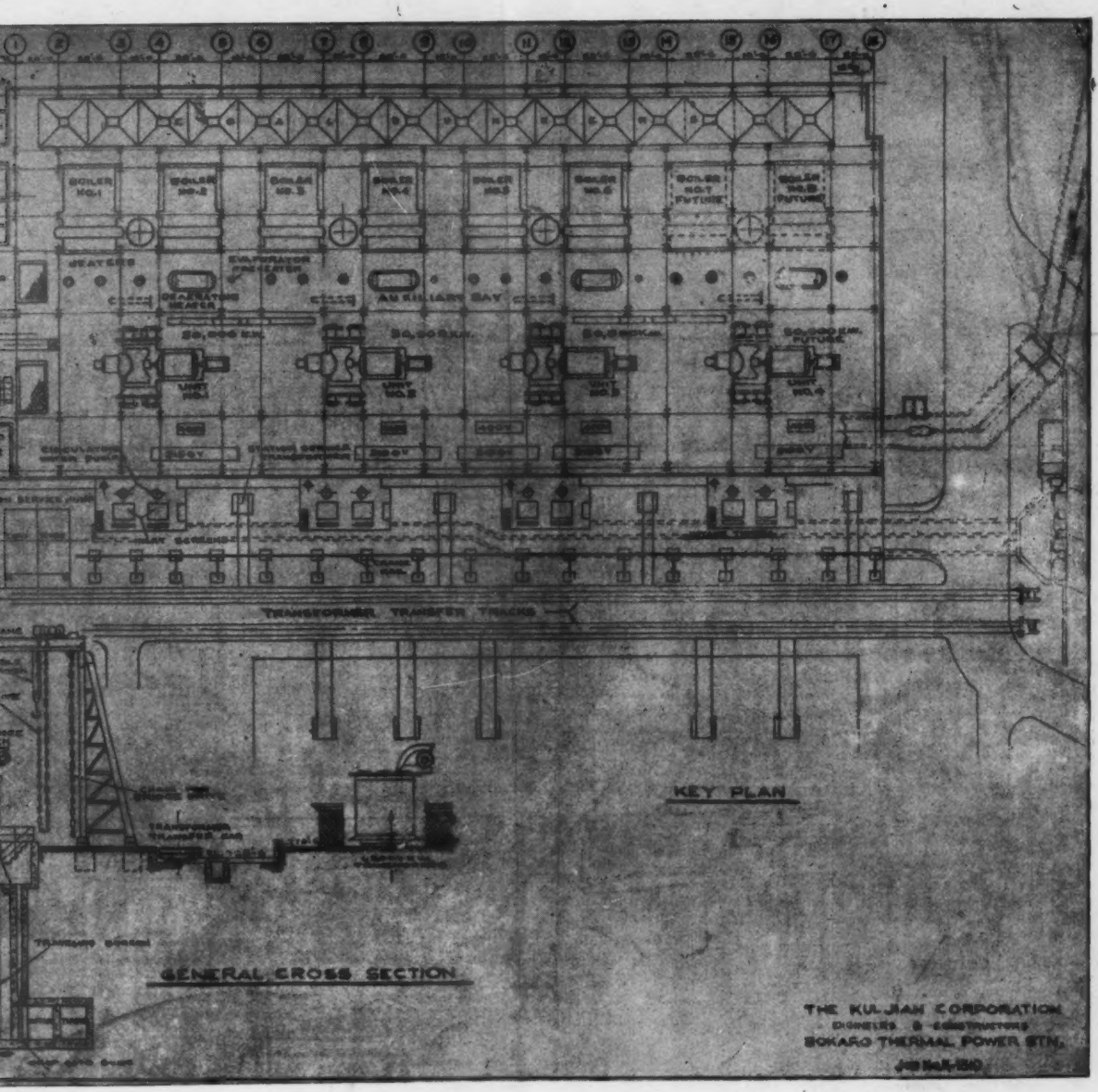

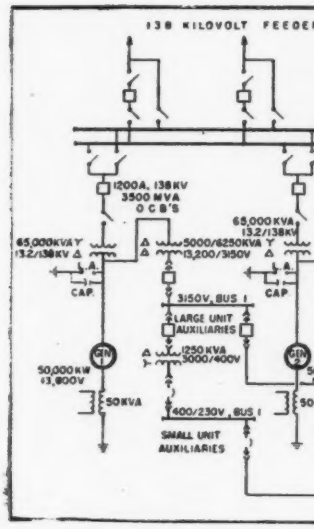
138 KILOVOLT FEEDE
1200A, 138KV
3500 MVA
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5000/6250KVA Y
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3150V, BUS 1
LARGE UNIT
AUXILIARIES
GEN
1250 KVA
5000/400V
50,000 KW
13,800V
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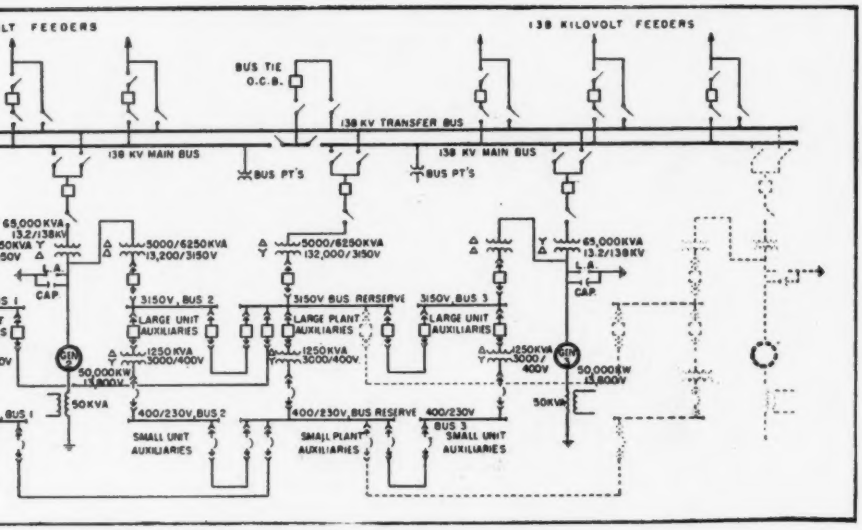
SMALL UNIT
AUXILIARIES



Single line diagram of the electrical system at Bokaro

V56 JUN 55 UMI

boilers, of which one is a standby. These pumps can deliver 600 gallons of hot water per minute at 316° F against a total head of 2,910 ft. to the high-pressure heat-exchanger and finally into the boiler drums. These heat exchangers have been provided with desuperheating, condensing and sub-cooling zones and condensate from these will be cascaded to the deaerator.

Raw make-up water from the river is pumped from the discharge tunnel through a coagulation and precipitation plant and a pressure filter to a Zeolite Softener. Softened water then passes through the evaporator deaerator to the evaporator. Sufficient quantity of steam for make-up requirement flows to the deaerating heater for condensation and storage. Any excess of steam from the evaporator is used in the evaporator deaerator.

Automatic Control

The units are designed to operate normally on automatic control under constant as well as varying load conditions. The turbine governing system is actuated hydraulically by oil pressure generated by a centrifugal pump on the turbine shaft. In general, the other mechanical control systems are operated by compressed air at 90 psi.

The combustion control system automatically and simultaneously accomplishes the following:

(*a*) Distribute the effect of fluctuating requirements of steam by the turbo-alternator on the two boilers equally.
(*b*) Control the fuel feed of each boiler to maintain the desired steam pressure at any load.
(*c*) Control the furnace draft, maintaining a negative pressure under normal operating conditions.
(*d*) Control the forced draft to maintain the required fuel-air ratio so as to give the best efficiency.
(*e*) Control the pulverizer mill temperature so as to avoid fire hazards or inefficient grinding due to wet coal.

The temperature of the steam leaving the superheater is controlled by means of a temperator installed in the piping between the primary and secondary superheater sections.

A feed water control actuated by steam and feed flow maintains the water level in the drum within close limits.

Another control regulates the water levels in feed water heaters and hot wells and thus prevents backfeed of steam from feed heaters to the turbine due to sudden load fluctuations.

Yet another automatic arrangement recirculates the boiler feed in case of low loads.

The main station controls are centralised, and there is no distinct separation between boiler and turbine boards. The control boards are fitted with indicating and recording instruments, automatic and manual control devices, alarms and push buttons for starting and stopping various equipment.

Two turbine and four boiler boards with master control form one control panel. It is located between two turbines in the Turbine Room.

To facilitate operation, an annunciator combined with internal telephone system, having access to all the important points in the Plant, has been installed.

Electrical System

Each of the three 50,000 kW generators is connected to the primary of a 65,000 KVA, 13.2/138 kV, forced oil/water-cooled, out-door type main step-up transformer, and also to its own unit auxiliary transformer rated at 6,250 KVA, 13.2/3.15 KV. The neutral of each generator is grounded through a 50 KVA grounding transformer having 220 volts secondary winding with a resistor across it. The generators have directly connected main and pilot exciters.

The generators are protected by differential relays. Differential protection has also been provided between each generator and its main transformer on one hand and the generator and its unit auxiliary transformer on the other. The ground fault relay on the 13.2 KV system is operated by a current transformer mounted in the secondary circuit of the grounding transformer.

The main step-up transformer is connected through 3,500 MVA, 138 KV, 1,200 Amp, outdoor type oil circuit breakers, to duplicate busbars, connecting to six outgoing feeders. The control boards for these breakers are located inside the power station building.

Auxiliary Power

The normal supply for the auxiliary power system of each generator is from the 6,250 KVA, 13.2/3.15 KV unit transformer. Each generator has its own 3.15 KV auxiliary bus supplying large motors at 3,000 volts and also an individual 1,250 KVA, 3,000/400-230 V, Pyranol immersed transformer for feeding low voltage motors and equipment.

In case of necessity, power to the station auxiliaries can be supplied from outside through a reserve transformer 6,250 KVA, 13.2/3.15 KV Delta—Star connected feeding a 3.15 KV reserve switch-board.

All motors in the station are derated for use in the tropical climate, in an ambient of 50°C.

Structural and Construction Details

The structural and the boiler supporting steel, has been made of heavy section rolled joists up to 3″ web thickness designed to economise on weights and enable quick erection, as well as to minimise damage during transport. A joint to take up expansion has

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been provided in the centre of the building. The boiler supporting steel is also designed to share the building load. The total steel involved is about 6,000 short tons.

The building is designed to take care of moderate earthquake shocks.

The main operating floor of the turbines and boilers is at ground level, and there is a basement 26 ft. below. The total height between the basement and the high roof is 118′-0″. The steel stacks, 86′ high, will be supported on the high roof. Light and ventilation for the basement and for all other floors has been provided.

The auxiliary transformers and the circulating water pumps are located outside the main building and will be served by a 25-ton outdoor gantry crane.

One 125-ton overhead travelling crane has been installed in the Turbine Room. The heaviest part lifted is the generator stator, weighing about 105 tons.

Essential Data

Steam Generators

Manufacturers	...	Combustion Engineering & Superheater Co. Inc.
Number (Initially)	...	Six
Type	...	VU
Capacity	...	300,000 lbs. per hour at 900 lbs./sq. in. 910° F.
Heat release rate	...	17,000 Btu/hr./cft. of furnace volume.
Coal	...	27 to 30% Ash fired as Pulverised fuel.
Steaming up time	...	From cold—10 hrs. From Weekend shut down—3 to 4 hrs.

Turbine Generators

Manufacturer	...	General Electric Co., U.S.A.
Number (Initially)	...	Three
Turbine Rating (Maxm.)	...	62,500 kW at 3,000 RPM & 850 lbs./sq. in. & 900° F Steam.
Electrical Rating	...	57,500 kW at 15 lbs./sq. in. Hydrogen pressure & 0.8 p.f. 50,000 kW at 0.5 lbs./sq. in. Hydrogen pressure & 0.8 p.f.
No. of Extractions	...	Five

Condensers

Manufacturers	...	Foster Wheeler Co.
Number	...	Three
Surface	...	50,000 sq. ft.
Cooling water	...	50,000 G.P.M.
Back pressure	...	1.7″ Hg. at 76° F.
Cooling water pumps	...	Two Nos. Vertical mixed flow 27,500 GPM at 720 RPM & 45′ head (each) per condenser.

High Pressure Piping

Material	...	Alloy Steel.
Manufacturers	...	Blaw-Knox Construction Co. Ltd.

Valves

High Pressure	...	Chapman—Motor operated.
Moderate Pressure	...	Crane Co., Chicago
1″ & below	...	Hancock Co.
Feedwater Valves etc.		Edward Co.
Extraction Valves	...	Attwood & Morril Co.

Water Treatment Plant

Coagulating & Precipitation Plant	...	Permutit Co., New York
Water Softening Zeolite Plant		Cochrane Corporation, Philadelphia.
Evaporator—Preheater (deaerating)		Worthington Machinery Co., New Jersey
Evaporator	...	Lummas Co., New York.

Coal Handling Equipment

Aerial Ropeway from Bermo		Kumardhubi Engineering Co.
Crushed Coal Storage		Drag Scrapers—upto 20′ high 300′ radius, for 2½ months operation.
Belt Conveyors, Capacity	...	2—250 Tons/hour
Belt Conveyors' Manufacturer		Link Belt Co., Philadelphia.

Control System

For Steam Generators & Turbine Generators		Centralised—One set of panels for 2 units.
For Auxiliary equipments		Separate panels for each unit.
Main suppliers	...	Bailey Motor Co., Cleveland.

Transformers

Manufacturers	...	General Electric Co.
Numbers	...	Three per unit.
Ratings—Main	...	65,000 KVA; 13.2/138 KV Forced Oil Water cooled outdoor, delta/star.
Station Service	...	6,250 KVA; 13.2/315 KV; oil immersed, self cooled, forced air cooled delta/delta.
Auxiliary	...	1,250 KVA; 3,000/400 & 250 Volts Pyranor (fireproof) immersed, self-cooled, forced air cooled, delta/star.

Barrage

Total Length	...	884 ft. (gated Barrage 678′, 206′ Afflux Channel).
River Bed Level	...	724 ft.
Water Level	...	743 ft.
Maxm. Flood Level	...	757 ft.
Road Level	...	767 ft.
Sluiced Openings	...	678 ft. length

Spillway	...	200 ft. length at high level
Storage Capacity	...	60 million cft.
Type of Construction	...	Solid Concrete with lift gates.

Elevations

Basement Level	...	742′-6″
Operating Flood Level		768′-6″
Lower Boiler Drum	...	874′-0″
Upper Boiler Drum	...	812′-0″
High Point of Building		860′-6″ (118′-0″ high from basement)
Top of Stock	...	946′-7″ (204′-1″ high from basement)

Efficiencies

Heat rate	...	11,000 Btu/kW Gen. output
Overall Thermal Efficiency		31% (approx.) on Gen. output.

Important Dimensions & Quantities

Building Size	...	448′ × 171′
Approx. Steelwork	...	6,000 short tons.
Approx. Excavation in foundations and grading	...	70 Lac cft.
Approx. qty. of concrete to be poured	...	6 Lac cft.
Intake Channel	...	1,150 ft. long, 352 ft. Tunnel
Discharge Channel	...	762 ft. long, 360 ft. Tunnel
Construction Stores space	...	60,000 sq. ft.
Railway siding	...	10,000 ft. length.

Some Important "Firsts"

Order placed	...	February 23, 1949
Ground Broken	...	December 29, 1949
Concrete poured	...	May 17, 1950
Steel raised	...	November 18, 1950
Boiler Drum raised	...	February 3, 1951
First set commission	...	February 21, 1953
Second set commission		August 6, 1953
Third set commission	...	October 15, 1953

Hydro-Electric Installations

The Damodar Valley projects were conceived for multipurpose benefits, the main objectives being flood control, irrigation and power generation. In the first phase of development, four major dams Tilaiya, Konar, Maithon and Panchet Hill are to be included.

Tilaiya

The Tilaiya dam is located on the river Barakar in the Hazaribagh district of the province of Bihar. It is situated approximately 70 miles to the north-west of Dhanbad and the nearest railway station is Kodarma on the Grand Chord line of the Eastern Railway.

The project consists of a concrete gravity type dam 1,147 ft. long with a maximum height of 99 ft. above the river bed. The spillway located in the river section is 510 ft. long including the piers. The flow of water over the spillway is controlled by 14 tainter gates. Two Harza type undersluice gates are in addition provided.

The power house is located on the left side of the dam looking downstream. The station building is a reinforced concrete structure with space for three vertical shaft francis turbine driven generating units each designed to develop 2,000 kW under a design nett head of 64 ft. Two units have now been installed and all necessary civil works in the dam have been completed for the installation of a third similar unit at a future date.

The power station comprises the turbine floor at elevation 1,146 ft. R.L. and the generator floor at elevation 1,159.25 ft. A 35 ton overhead travelling crane, having a span of 31′-2″ services the generator floor. The excavation and foundation for the power station extend 27 ft. below the turbine floor. Suitable access to the draft tube has been provided at elevation 1,131.58 ft.

The Control room, switchgear room and the cable gallery are provided on the upstream side of the power house, supported at one end by the power house wall and at the other end by suitable supports built on the apron of the dam.

Each unit is provided with an individual intake opening from the reservoir, rectangular in shape and formed in the concrete. It is provided with trash rack screens and an emergency vertical lift sluice gate operated from the top of the concrete dam. An 8″ bypass valve with strainer and piping has been provided to equalise the pressures on either sides of the emergency gate before opening. The bypass valve is operated from the drainage gallery inside the dam. A 12 inch air vent pipe has also been provided to release the entrapped air when filling the penstock.

The rectangular intake gradually tapers into a circular section and joins the $\frac{1}{4}$″ thick plate steel penstock of 7.5 ft. dia. at the upper end. The penstock joins the 6′10.5/8″ dia main inlet valve at its lower end.

Each generating unit comprises a Vertical Francis turbine and a synchronous generator, solidly coupled through an intermediate shaft. The guide bearings are located one above the turbine, one below and one above the generator rotor. The thrust bearing is housed integral with the top guide bearing. The main and pilot exciters are mounted above the combined guide and thrust bearing. A drawing showing the sectional arrangement of the Intake and Power House is reproduced.

Each Francis type turbine, manufactured by M/s Mitsubishi Heavy Industries Reorganised Ltd., Japan, at the Kobe Shipyard and Engine Works, is designed

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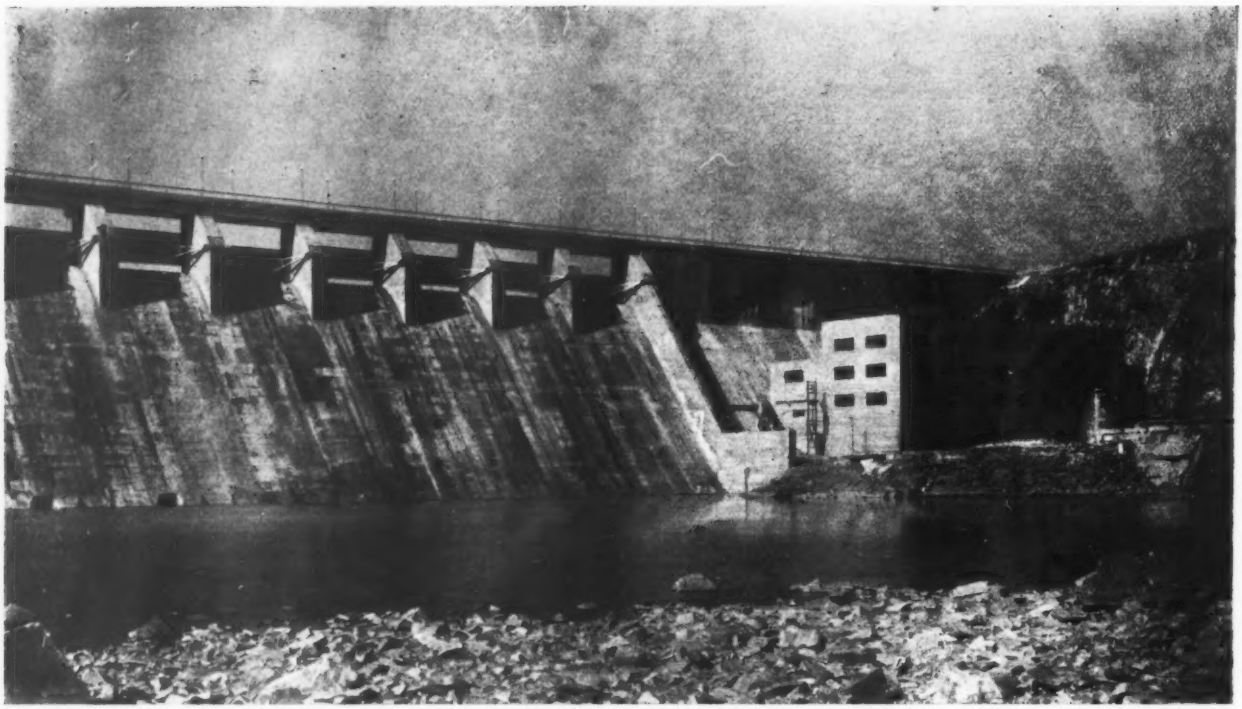
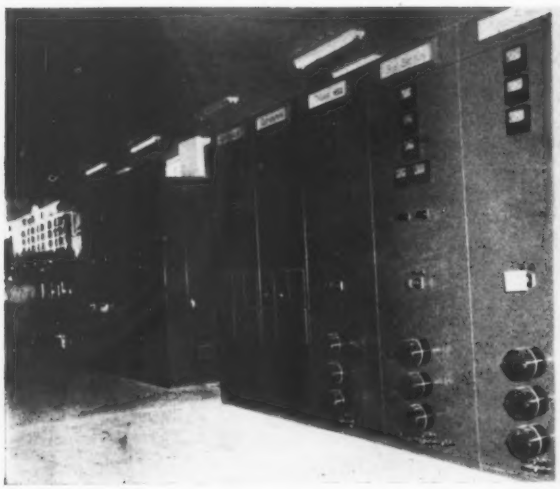
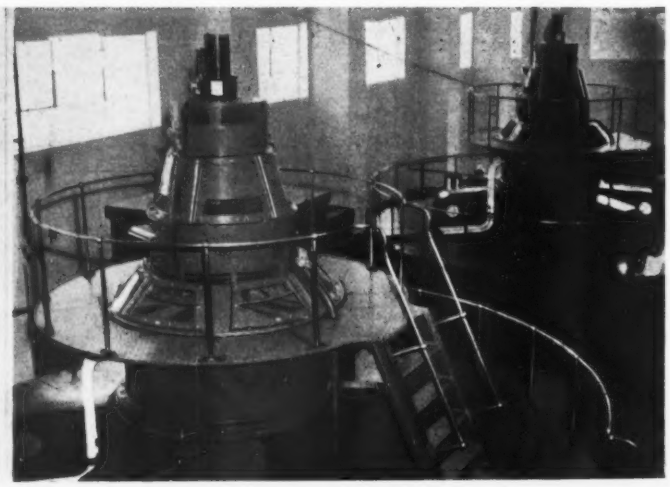


Tilaiya Dam and Power-house (downstream view).



Control room inside Power-house, Tilaiya.



Power-house machines (turbines), Tilaiya

to operate between a nett head range of 49 ft. to 82 ft. and to deliver an output of 2,800 B.H.P. at a speed of 250 RPM under the design nett head of 64 ft., and is equipped with steel spiral casing, main inlet valve of butterfly type, plate steel lined draft tube and accessories.

The speed of each turbine is controlled by a 18,600 ft. lb. automatic oil pressure governor provided with actuator, servomotor, return motion mechanism, manual control device etc. The actuator is equipped with speed level adjusting and load limiting devices, gate opening indicator and tachometer. Locking device is also provided to lock the servomotor piston when the generating unit is at standstill. The oil pressure system comprises on oil pressure receiver, oil sump, two rotary gear type oil pumps etc. The main pump is driven by an A.C. induction motor and the standby pump is driven by an auxiliary water turbine of the Francis type.

Each of the two main generators manufactured by Messrs. Mitsubishi Electric Mfg. Co. of Japan, is rated 2,500 KVA, 11 kV, 0.8 p.f., 3 phase, 50 cycles, 250 r.p.m. and is of the vertical shaft revolving field type. The generator has a 20% overload capacity for 2 hours. The generation voltage is 11 kV$\pm$10%.

The thrust bearing is of the Kingsbury type located on the generator upper bracket and of sufficient capacity to support the total weight of the generator rotating parts, turbine runner and the unbalanced hydraulic thrust.

The main exciter directly connected to the generator shaft is of the differential shunt wound type and rated 40 kW, 250 Volts. The pilot exciter is compound wound and rated 3 kW, 110 volts. Each generator is provided with an automatic, exciter rheostatic type of voltage regulator for maintaining the generator voltage constant at 11 kW. The main single line diagram of the indoor and outdoor electrical equipment is shown here.

The outdoor switchyard is situated approximately 100 yards from the Power House on the downstream side and on the left bank of the tailrace channel.

The layout is essentially a three breaker arrangement as shown in the attached key diagram and consists of the following major equipment:—

(*a*) Two Power Transformers of the outdoor, oil-immersed natural cooling type (ON) and rated 2,500 kVA, 11 kV/33 kVA, connected Delta/grounded Star.
(*b*) Two, bulk-oil circuit breakers, outdoor type, 3-tank unit, rated 33 kV, 400 amp., 500 MVA, controlling the H.T. side of the transformers and the two outgoing 33 kV lines.
(*c*) One bulk-oil circuit breaker rated 33 kV, 400 amp., 500 MVA for Bus-Tie.

The primaries of the transformers are connected through 150 MVA OCBs to the 11 kV indoor bus by means of paper-insulated power cables.

The control system is such that the generating units can be automatically started up and synchronised to the bus. The automatic starting is carried out by the main controlling switch, located in the control room. Signal lamps are provided in the control room to show the steps through which the generating unit passes in the starting sequences. Provision has been made to stop the unit if the sequences are not properly carried through.

The erection of No. 2 unit was taken in hand in September 1952 and was completed on 26th January 1953 when the unit was started up under manual control. The unit was put on commercial load on 21st February 1953, the day of the opening ceremony of Tilaiya Project performed by the Prime Minister of India. No. 1 generating unit was commissioned on 10th July 1953.

Maithon

The Maithon Dam is located on the river Barakar on the border of Bihar and West Bengal. It is situated 15 miles north west of Asansol and 25 miles east of Dhanbad. This Dam is primarily meant for flood control purposes.

The project consists of a main rolled earth dam across the river bed with a gravity type concrete section on the right bank over the diversion channel, a diversion tunnel on the left bank and the right bank dyke and saddle dykes. The height of the dam above the river bed is 162 ft. and the lengths of the main earth dam and the concrete dams are approximately 2,061 ft. and 612 ft. respectively. The spillway in the concrete dam is provided with 12 nos. tainter gates and 6 nos. undersluices.

The power house is located underground on the left bank of the river looking downstream, approximately 200 ft. below ground level. The station is equipped with three horizontal shaft Francis Turbine driven generating units, each designed to develop 20,000 kW under a nett head of 113 ft.

Access to the power house is by a concrete lined tunnel with a maximum gradient of 12 percent. A vertical emergency exit shaft equipped with a spiral stair case is provided at the other end of the power house. The generators are situated in the main power house floor whereas the turbines are placed inside separate vaults. The turbines discharge into a single chamber which is connected with the diversion tunnel by three individual tailrace tunnels. The power house floor is at an elevation of 328 ft. and the basement floor below at elevation 310.5 ft. houses the generator coolers, station auxiliaries, bus duct and cable and pipe galleries. A 115 ton overhead travelling crane having a span of 42 ft. services the machine hall. Handling of equipment inside the turbine

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vaults is facilitated by the use of three overhead monorails equipped with two electric hoists of 10 tons each.

A separate intake structure of the concrete gravity type is provided in the reservoir. Each unit is provided with an individual intake opening rectangular in shape and provided with trash rack screens. The rectangular intake gradually tapers into a circular section and joins a plate steel penstock of 14 ft. diameter reducing to 13 ft. at the spiral inlet. The entire penstock is embedded in the rock. The intake is serviced by a vertical lift gate provided with rollers rotating in *antifriction bearings*. The gate is operated by an electrical hoist provided on the intake deck and is capable of remote control from the power house. In addition one emergency gate for the three intakes is provided to facilitate servicing the main intake gates. A gantry crane travels on the intake deck and serves to handle the gates and the trash racks, during servicing.

Each generating unit comprises a horizontal shaft Francis turbine with straight conical plate steel draft tube and a synchronous generator solidly coupled through an intermediate shaft. The unit is provided with two guide bearings for the generator and a combined guide and thrust bearing for the turbine. The main exciter is directly connected to the generator shaft whereas the pilot exciter, rapidyne for voltage regulation and the permanent magnet/ generator for the governor fly balls are gear driven at a speed of 1,490 rpm.

The turbines manufactured by Messrs. Establishments, Neyrpic, Grenoble, France, are each designed to operate between a nett head range of 79 ft. to 127 ft. and to deliver a maximum output of 27,750 BHP at a speed of 176.5 R.P.M. The welded plate steel spiral casing has an inlet diameter of 13 ft. The cast steel runner is one piece, has an outlet diameter of nearly 10 ft. and weighs 17.25 tons. Two oil pressure servomotors of a combined capacity of 167,000 ft. lbs operate the guide vane mechanism.

The speed of the unit is controlled from an oil pressure actuator type governor enclosed in a steel cabinet with all controls and instruments mounted on the front panels of the cabinet. Two 24 HP A.C. motor driven pumps are provided to supply pressure oil to the governor and servomotors under normal conditions and one 6 HP D.C. motor driven pump is provided for emergency operation.

The generators manufactured by Messrs. Siemens Schuckertwerke, Erlangen, West Germany, are each rated for 25,000 KVA, 11 kV, 0.8 power factor, 3 phase, 50 cycles, 176.5 RPM and are of the horizontal shaft salient pole construction type. The assembled rotor with its shaft weighs approximately 110 tons and the total flywheel effect incorporated amounts to 7.9 million lb-ft^2.

The main exciter directly connected to the generator shaft is raised 148 kV 310 volts at rated generator output. The pilot exciter which is gear driven from the main shaft, is rated 3.6 kW at 230 volts.

The generator voltage is regulated at a preset value by means of a rotary d.c. amplifier which controls the exciter output.

The main generator transformers manufactured by Messrs. ASEA of Sweden are of the forced oil water cooled type each rated for 25,000 KVA, 0.8 p.f. 11/33 kV, 3 phase. They are located underground alongside the access tunnel adjacent to the power house.

The entire generating unit including the transformer is capable of sequential parallel semi-automatic starting and stopping operation up to the stage of synchronising.

The outdoor switchyard is situated approximately 550 yards from the underground power house and the main control room is located alongside the switchyard.

The power house excavation is well under way and the erection of the equipment is scheduled to commence immediately after the 1955 monsoons. The first generating set is expected to go into operation before the middle of 1956.

Panchet Hill

The Panchet Hill dam is located on the river Damodar in the Manbhum district of Bihar approximately 3 miles above its confluence with the Barakar. This dam is also primarily meant for flood control purposes.

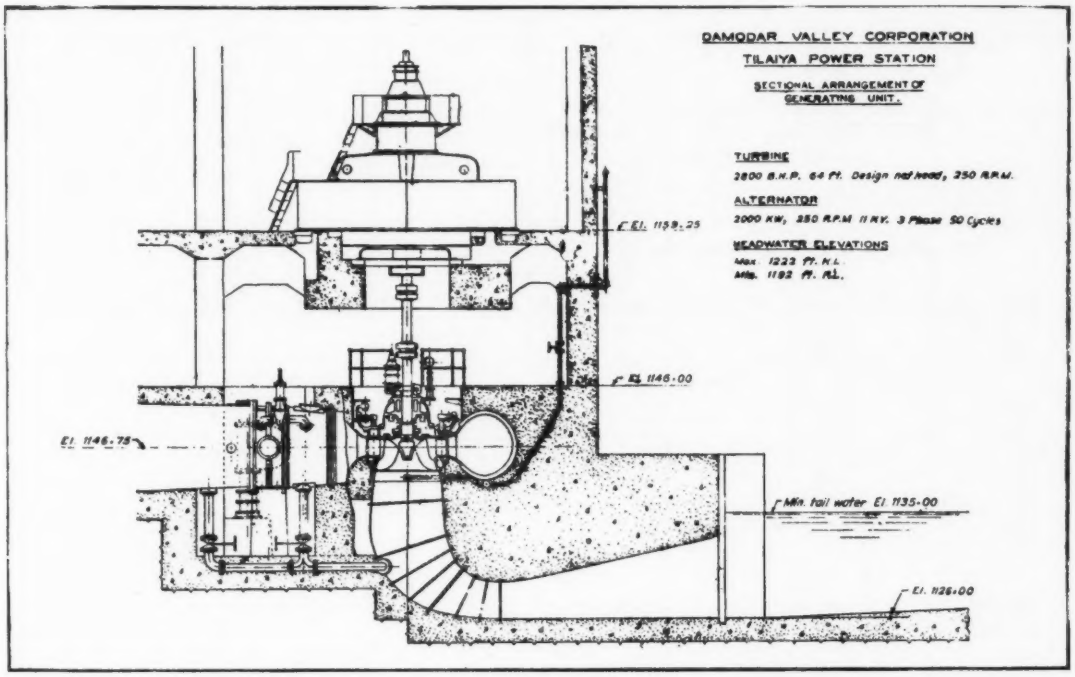
The main dam is designed as a rolled earth type dam with a gravity concrete spillway. The average height of the dam above the river bed is 132 ft. and the lengths of the main earth dam and the concrete portion are approximately 7,235 ft. and 765 ft. respectively. The spillway on the left bank is provided with 15 nos. tainter gates and 10 nos. undersluices.

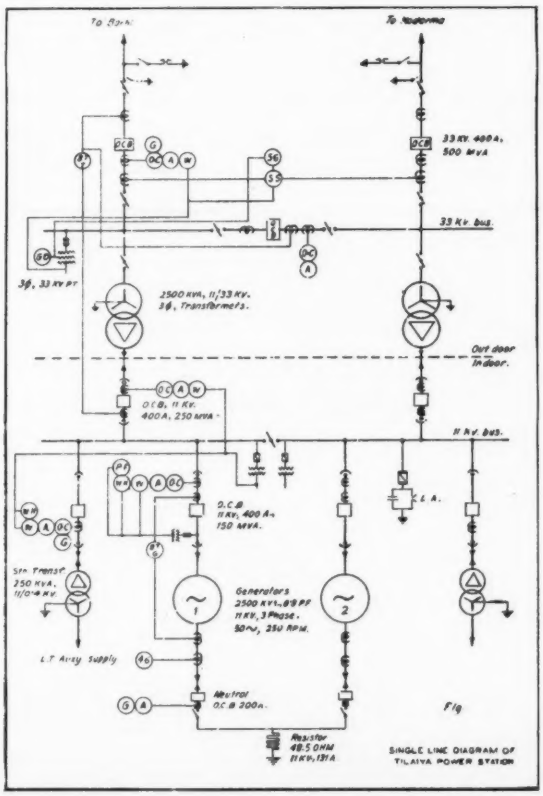
The power house of the conventional type will be located on the right side of the spillway looking downstream. The ultimate installation will consist of two vertical shaft Kaplan Turbine driven generating units each designed to generate 40,000 kW under a nett head of 81 ft. Only one unit is being installed initially. However, all necessary civil works in the dam will be completed for the second unit also.

Orders for the main equipment for the initial installations are expected to be placed shortly. The generating unit is scheduled to be commissioned during 1957.

Konar

The Konar dam is located on the river Konar in the Hazaribagh district of Bihar. The nearest railway




To Bdn.
To Transforma
33 KV. 400 A. 500 MVA
33 Kv. bus.
3φ, 33 KV PT
2500 KVA, 11/33 Kv. 3φ, Transformers.
Out door
Indoor.
O.C.B. 11 KV. 400 A. 250 MVA.
11 Kv. Bus.
L. A.
O.C.B 11 KV, 400 A. 150 MVA.
Stn. Transf 250 KVA. 11/0·4 Kv.
Generators 2500 KVA. 0·8 PF 11 KV, 3 Phase. 50~, 250 RPM.
L.T. Aux. Supply
Neutral O.C.B 200 A.
Resistor 48·5 OHM 11 KV, 131 A
SINGLE LINE DIAGRAM OF TILAIYA POWER STATION
Fig

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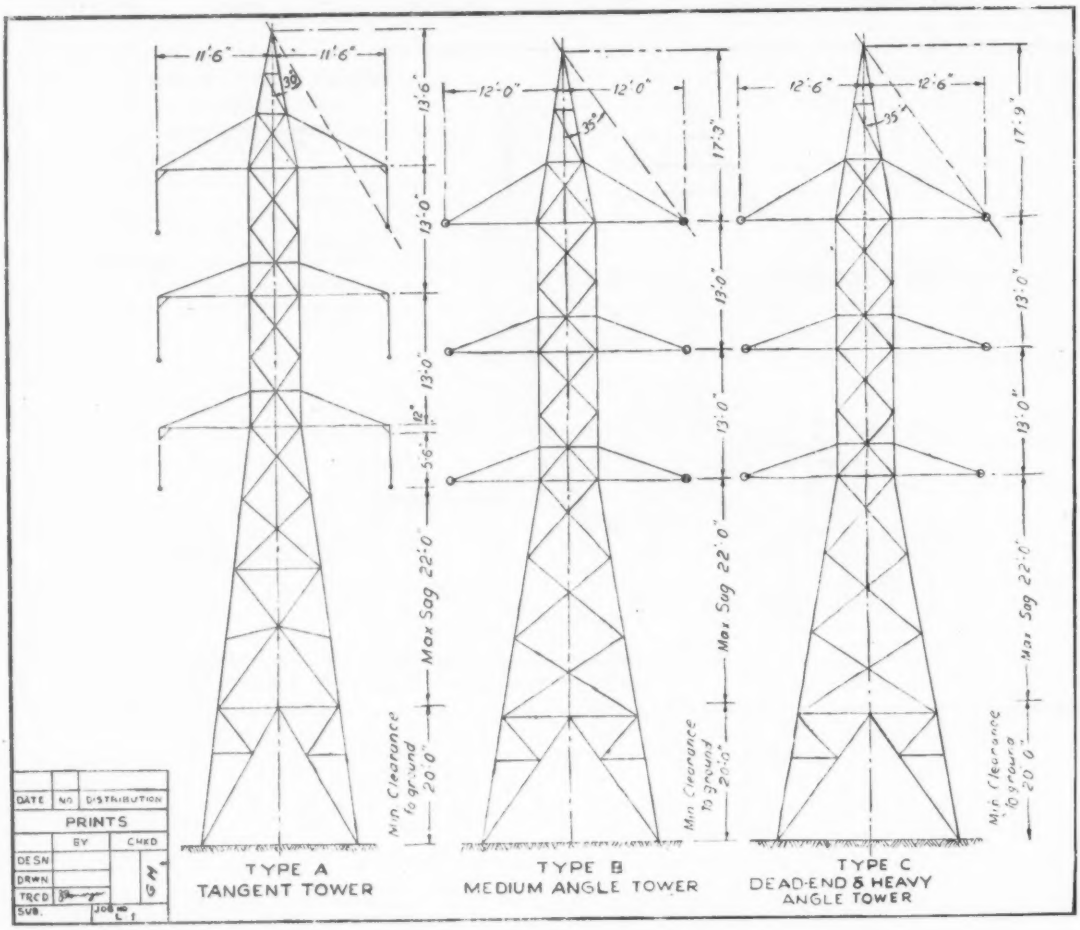

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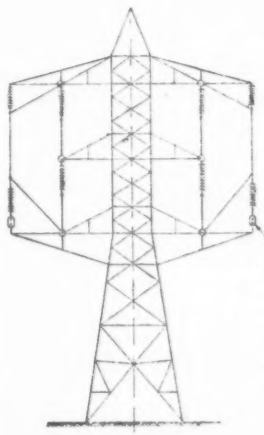
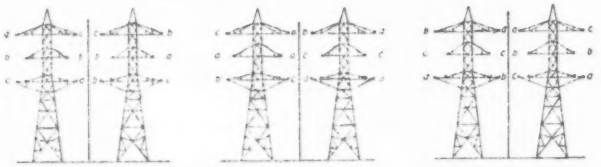
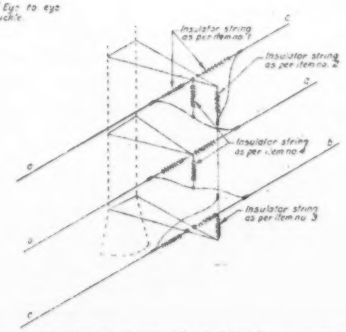


TRANSPOSITION TOWER



FIRST TRANSPOSITION TOWER — SECOND TRANSPOSITION TOWER — THIRD TRANSPOSITION TOWER

ARRANGEMENT OF CONDUCTORS OVER ONE COMPLETE TRANSPOSITION


Insulator string as per item no 1
Insulator string as per item no 2
Insulator string as per item no 4
Insulator string as per item no 3

DIAGRAMMATIC SKETCH OF CONNECTIONS

ITEM NO.	LENGTH OF THE COMPLETE INSULATOR STRING ASSEMBLY.
1	60"
2	79"
3	Min 101" Max 113"
4	66"

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DAMODAR VALLEY CORPORATION
ELECTRICAL DEPARTMENT

D.V.C. POWER TRANSMISSION SYSTEM

132 KV DOUBLE CIRCUIT LINE
METHOD OF TRANSPOSITION.

DY. C.E.E.

DATE

DRG NO T-830

REV NO	DATE	NATURE OF REVISION	BY	SANCTIONED

station is Gumia on the Barkakana loop of the Eastern Railway.

The dam is of the concrete gravity type about 910 ft. long and a maximum height of 162 ft. above the river bed and has contiguous earth embankments and saddle dykes. The spillway in the concrete dam is provided with 9 nos. tainter gates and 2 nos. undersluices. The construction of the dam was completed in 1954.

The project provides for the construction of an underground hydro-electric power station equipped with two vertical shaft Francis turbine driven generating units each designed to develop 20,000 kW at a nett design head of 500 ft. The tailrace tunnel will be more than 7 miles in length.

The water releases from the Konar dam serves the additional purpose of providing cooling water to the Bokaro Thermal Power Station.

The work on the hydroelectric power station will be taken up as soon as the necessary sanction for the same is given by the Governments concerned.

Some Data on Reservoirs and Hydroplants of Tilaiya, Konar, Maithon and Panchet Hill

Particulars		*Tilaiya*	*Maithon*	*Panchet Hill*	*Konar*
1. Total drainage area sq. mls.		380	2,430	4,234	385
2. Reservoir levels:—					
(*a*) Bed level	ft.el.	1,140	350	320	1,256
(*b*) Dead Storage	,,	1,192	435	392	1,347
(*c*) Spillway Crest	,,	1,212	460	405	1,372.5
(*d*) Top of Gates	,,	1,222	500	445	1,402
(*e*) Top of Dam	,,	1,234	512	457	1,415
(*f*) Power pool (Max.)	,,	1,222	480	410	1,402
3. Reservoir Storages:—					
(*a*) Capacity to top of gates	AC.ft.	320,000	1,104,000	1,214,000	260,000
(*b*) Dead Storage	,,	61,000	168,000	148,000	49,000
(*c*) Live storage for Irrigation & Power	,,	259,000	496,000	185,000	211,000
(*d*) Controlled Storage for flood	,,	Nil	440,000	881,000	Nil
(*e*) Uncontrolled Storage for flood	,,	131,000	Nil	Nil	38,000
4. Submerged Areas: Top of Gates	Acres	14,500	26,500	37,900	6,200
5. Spillway Gates:					
(*a*) Number		14	12	15	9
(*b*) Type		Taintor	Taintor	Taintor	Taintor
(*c*) Size		30′×10′	41′×40′	41′×40′	34′×29.5′
6. Sluice Gates					
(*a*) Number		2	6	10	2
(*b*) Size		30″ dia	5′3″×10′	5′8″×10′	7½′ dia.
7. Power House—Type		Conventional	Under Ground	Conventional	Under Ground
8. Turbines:					
(*a*) Type		Francis	Francis	Kaplan	Francis
(*b*) Arrangement		Vert. steel Spiral	Hor. steel Spiral	Vert. steel Spiral	Vert. steel spiral
(*c*) Number of units					
(*a*) Present		2	3	1	
(*b*) Ultimate		3	3	2	2
(*d*) Operation heads	ft.	49/82	79/127	66/84	471/541
(*e*) Rated capacity each,	BHP	2,800	27,750	56,000	28,000
(*f*) Speed	RPM	250	176.5	125	—
9. Generators:					
(*a*) Rated capacity each,	KVA	2,500	25,000	47,060	23,530
(*b*) Power factor		0.8	0.8	0.85	0.85
(*c*) Generation voltage	kV	11	11	11	11
(*d*) Flywheel effect lb. $ft^2 \times 10^6$		0.296	7.9	35	—
10. Step-up Transformers:					
(*a*) Type		ON	OFW	OFW	—
(*b*) Voltage ratio		11/33	11/33	11/132	11/132
(*c*) Rating KVA		2,500	25,000	47,060	23,530
11. Annual Energy generation 10^6 KWHS		22.7	190	210	189

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Transmission System

Power will be distributed over an area of about 35,000 square miles by a transmission system stretching from Patna and Dalmianagar in the west to Calcutta in the east. The system will consist of 723 miles of 132 kV lines, 114 miles of 33 kV lines, 15 grid substations and 17 receiving stations. The system has been planned to meet the immediate requirement of the Valley but it has been made sufficiently flexible to take care of the future extensions and if required, interconnection with the neighbouring power systems.

Upto the present the transmission line from Bokaro to Jamshedpur and from Bokaro to Kalipahari near Ranigunj has been constructed the work on other sections is in progress. The system as is expected to be completed by the end of 1957.

Transmission Towers

132 kV transmission tower is of latticed steel type, suitable for double circuit with one ground wire on top. Overall height of the tower is 90 feet. For normal towers, three equal cross arms are provided which allow a horizontal conductor spacing of 23 feet. Vertical distance between cross arms is 13 feet. Tower to conductor clearance of 6 feet and above is provided. Midspan conductor clearance (vertical) is 13 feet.

Six types of 132 kV towers are being used. These are enumerated below:

A — Tangent towers for straight runs, 11,00′ span.

AA — Towers suitable for runs with deviation angle upto 5° with 1,100′ span. Also for longer spans with smaller angles.

B — Strain towers for use upto 30° angle and normal span (1,100′). Also for longer span and smaller angles.

BT — Transposition towers—for effecting one third of a complete transposition for both circuits and is similar in design to B type towers but with modified cross arms.

C — These are suitable for dead ends and for angles upto 60° with normal spans. Also for longer spans with smaller angles.

D — These are for use on 90° deviations on the line and for spans upto 1,100′. These towers are capable of withstanding full conductor and ground wire tensions.

For 33 kV distribution locally fabricated H-type structures made of rails is being used. Overall height of these structures is 34′; vertical distance between cross arms is 4′; horizontal distance between conductors is 8′ and tower to conductor is 2′-3″.

Tower foundations are of concrete and are designed to withstand full horizontal and vertical loads. Counterpoise wires are used to minimise tower footing resistance wherever the value exceeds 20 ohms. At other places pipes and rods are used as ground Electrodes.

Based upon the design load for the ultimate development, the 132 kV line has been provided with 37/.1151″ ACSR (Aluminium 30/.1151″) equivalent to 0.2 sq. in copper. Brief particulars of the conductors are given below:

(*a*) Overall diameter — 0.806 inch.

(*b*) Ultimate strength —20,000 lbs.

(*c*) Maximum design working tension at 35° F — 8,000 lbs. at 2.5 factor of safety.

(*d*) Maximum sag in still air at 140° F —22 ft.

On the 33 kV distribution lines a smaller size ACSR conductor 7/.1878″ equivalent to .1 sq. in. is used.

Most of the DVC 132 grid transmission line traverses the coalfields of West Bengal and Bihar and the adjoining mineral belts of the rich Gondwana which is highly susceptible to lightning disturbance during the monsoon. A study of the isoceraunic level has indicated that about 70 to 80 thunderstorm days/year is obtained in this area. The problem of likely outages of the transmission line due to direct lightning stroke has been carefully studied, as a result of which the following measures in the design and construction of the 132 kV line have been adopted.

(*a*) An earthwire (19/.1151″ ACSR) is provided on the top of the double circuit tower at such a position as to make a shielding angle of approximately 30 with the vertical while the electrostatic field will just shield the top conductor. This "protective angle" of the earthwire would cause the lightning stroke to bypass, saving the line conductors.

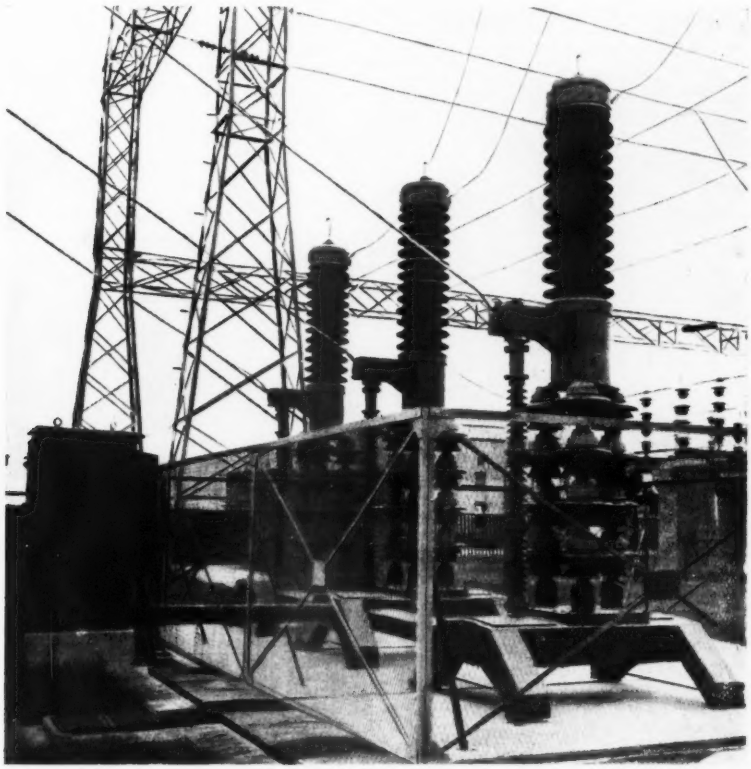
(*b*) The "tower footing impedance" is limited to 10 ohms by installing ground electrodes and/or counterpoise wires at each tower.

(*c*) The "midspan clearance" between the earthwire and the top conductors is limited to a minimum of 22 ft. measured along the inclined plane embodying them.

The above measures are designed to ensure limitation of the outage of the line to less than two times per 100 miles annually, against lightning strokes having the assumed value of 100,000 amps current magnitude.

The 132 kV line insulators are of standard suspension type 10″ dia. These comprise 9 discs for normal suspension staring and 10 discs for the corresponding strain type. The flashover voltages for 9 discs unit at 60 cycles is 540 kV dry and 375 kV wet. The corresponding figures for 10 disc insulator are 590 kV and 415 kV respectively.

The 33 kV insulators are of 3-shell, Pin type insulators 14″ high with dry and wet flashover voltages of 145 kV and 100 kV respectively.



132 kV Low Oil Content Circuit Breaker at Bareilly Substation

ASEA LOW OIL CONTENT CIRCUIT BREAKERS ARE OF MODERN DESIGN AND OF PROVED DEPENDABILITY. THEY HAVE ARC EXTINGUISHING CHAMBERS OF CONTRACTION TYPE WHICH OPERATE QUICKLY AND SMOOTHLY AT ALL LOADS.

OVER ONE HUNDRED **ASEA** OIL CIRCUIT BREAKERS OF THIS TYPE FOR 33 TO 132 kV SERVICE HAVE BEEN INSTALLED IN, OR ARE ON ORDER FOR, INDIA.

ASEA
ELECTRIC INDIA, LIMITED

BOMBAY **CALCUTTA** **MADRAS**

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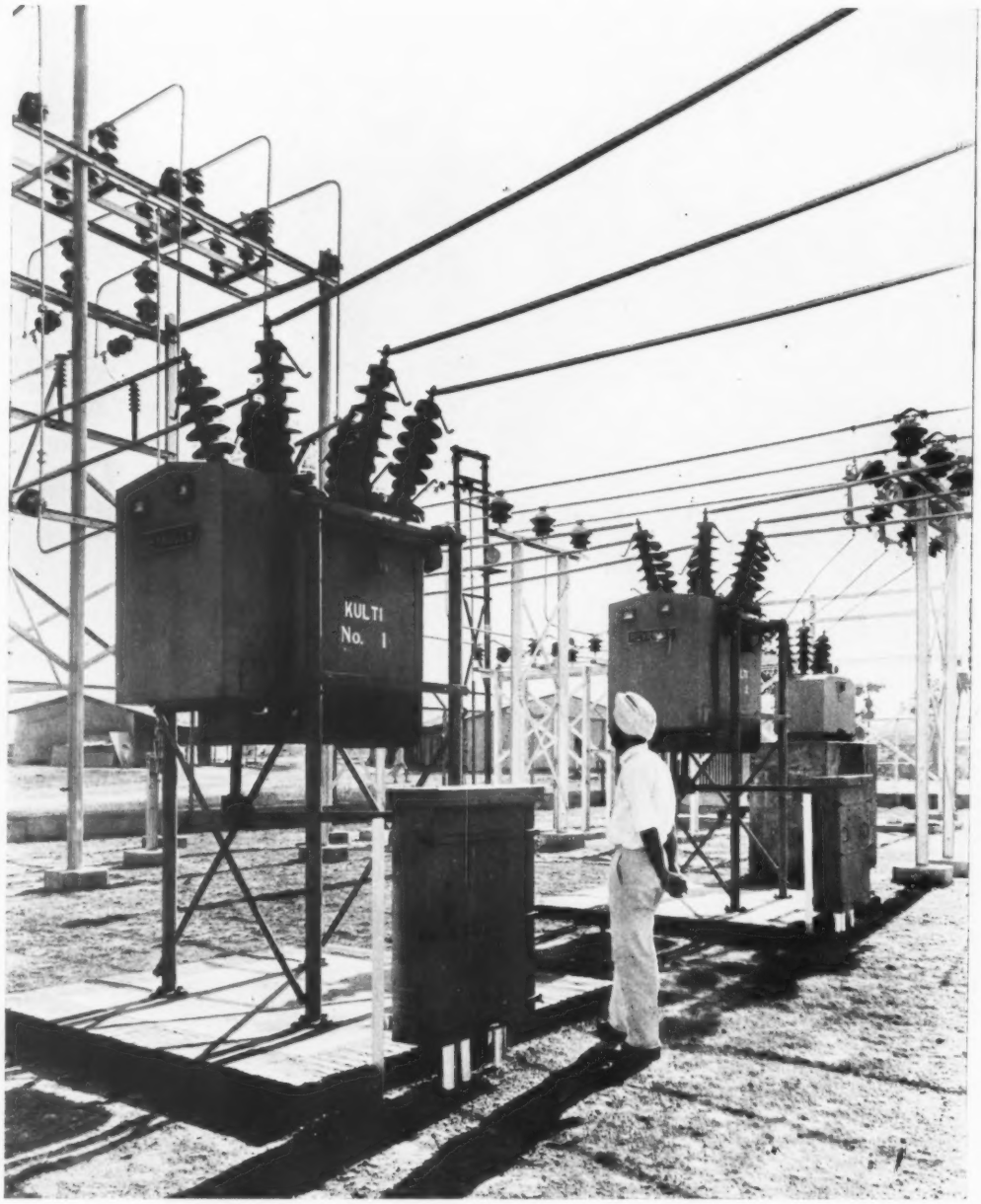
REYROLLE SWITCHGEAR



REYROLLE TYPE "ORT2" 33000 VOLT SWITCHGEAR AT MAITHON SUB STN.
AS SUPPLIED TO D. V. C. & OTHER USERS IN INDIA, IN LARGE QUANTITIES

Agents :

BURN & CO., LTD.
CALCUTTA BOMBAY NEW DELHI

BOMBAY CO. LTD.
MADRAS & SOUTHERN INDIA

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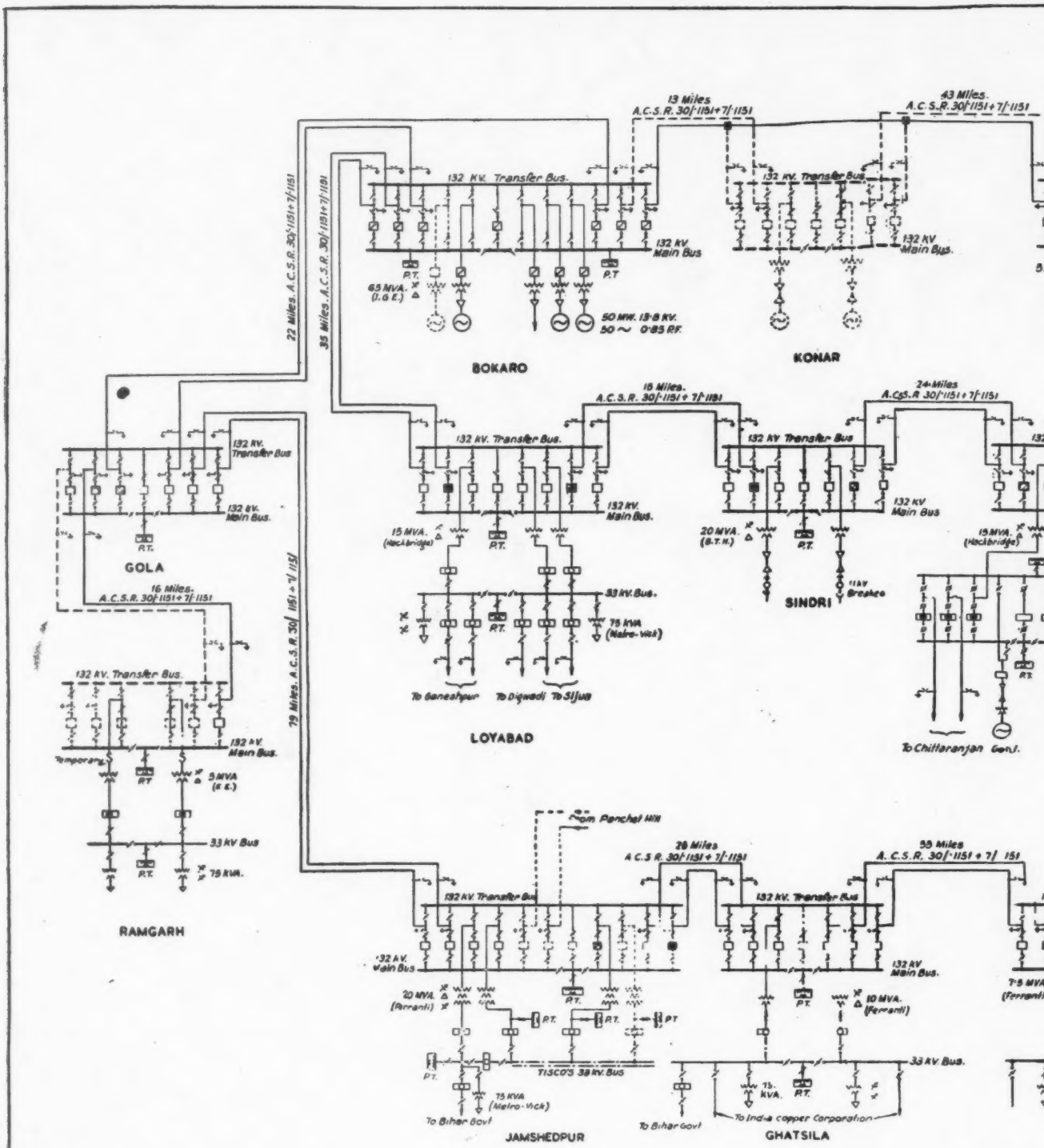

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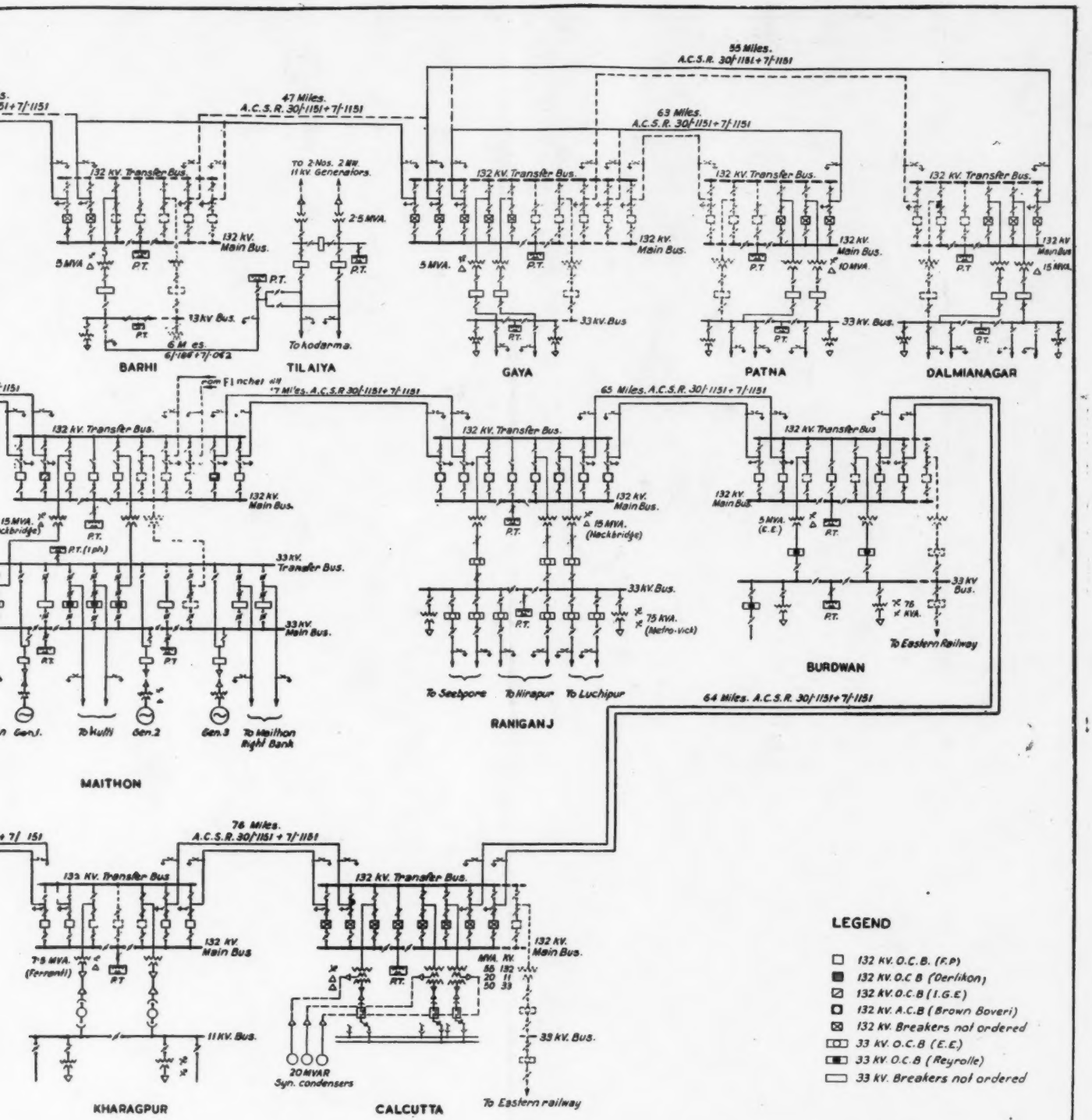


LEGEND

- 132 KV. O.C.B. (F.P)
- 132 KV. O.C.B (Oerlikon)
- 132 KV. O.C.B (I.G.E.)
- 132 KV. A.C.B (Brown Boveri)
- 132 kV. Breakers not ordered
- 33 kV. O.C.B (E.E.)
- 33 KV. O.C.B (Reyrolle)
- 33 KV. Breakers not ordered

DAMODAR VALLEY CORPORATION

ELECTRICAL DEPARTMENT

132 KV. SYSTEM

SINGLE LINE DIAGRAM

REVNO	DATE	NATURE OF REVISION.	BY	CHKD	APPD
3	17.7.54	Modifications upto June '54 included		GM	
2	15.12.53	Extensions to Patna & Dalmianagar added and drawing modified		GM	
1	24.7.53	Drawing modified.			

K.M.C. Chinnappa — DY.C.E.E. — C.E.E

P. Mukherjee — PROJECT ENGINEER

DATE 22.8.52. — DRG. NO S-P 30

Substation Design

For 132 kV switchgear, transfer bus layout is adopted. Layout of a typical substation is illustrated here. The arrangement permits a feeder breaker or a transformer breaker to be taken out, one at a time for maintenance and repairs. This is achieved by connecting the feeder on to the transfer bus directly by closing the transfer isolator and thence to the main bus by closing the bus-coupler breaker and the associated isolators. Bus-Coupler breaker thus protects the particular feeder during such transfer.

This arrangement is cheaper than the conventional double-bus layout with bye pass on one busbar in that the number of isolators required for one feeder is reduced by two.

For 33 kV switchgear a single busbar layout is adopted. As duplicate circuits are provided for most of the feeders, continuity of supply can be maintained excepting during a busbar fault which however rarely occurs. At Maithon Substation a transfer bus layout similar to those of 132 kV switchgear is adopted. The expense of transfer bus layout for this station appeared justifiable, as there would be a power station at Maithon and several important feeders will emanate from the 33 kV side

Transformers

At the Grid Stations both stepup and stepdown transformers have been provided, stepup units being necessary for interconnection of the power station with the grid. All transformers are of 3 phase core type construction and range from oil immersed 5 to 65 MVA. Attempts have been made to standardise on the interphase connection with star connected H.V. and Delta connected L.V. windings so connected that the vector of H.T. will lead that of L.T. by 30°.

There have been deviation however at one or two places. At Jamshedpur the 20 MVA transformers are star/star connected with an unloaded tertiary. The 55 MVA transformer provided at Howrah for supply to CESC are 3 winding units with two secondaries for supply of power at 33 kV and for supplying one 20 MVA condensor at 11 kV.

The step down units have generally a ratio of 132/33 kV and the step-up units have different ratios depending on the generating voltage either 11 or 13.8 kV.

Four principal types of cooling namely, ON, ON/OB, ON/OFW have been adopted for the transformers depending on the size and the location of the units.

The stepdown transformers are provided with $\pm 10\%$ on load tap on H.T. winding with one or two exception where taps have been provided on the L.T. but to cater for variation on the H.T. The on-load taps are all remote electrically operated with provision for manual operations. The step up units are provided with OFF load taps on the H.T.

The neutral of the 132 kV winding in all cases is solidly grounded and delta L.T. is grounded through a high impedance grounding transformer or left ungrounded if it is directly connected to the generator.

Circuit Breakers

Major portion of the circuit breakers to be installed in the initial stages would be of the bulk oil type; a certain number of the "minimum oil" type, and air blast breakers are also being installed. The calculated three-phase fault MVA in the DVC system does not exceed 2,500 MVA; the 132 kV bulk oil breakers will have a rupturing capacity of 2,500 MVA and the "minimum oil" and air blast breakers 3,500 MVA, with breaking times 4 to 5 cycles at 100% rated breaking current. All the breakers will be provided with high speed "auto reclosure" mechanism which is expected to reduce the problems of transient stability and ensure speedier restoration of supply. The bulk oil breakers will be pneumatically operated; while the minimum oil breakers will have motor-operated spring closing mechanism.

Much has been wirtten on the relative merits and demerits of bulk oil breakers, minimum oil breakers and air blast breakers although the latter are being worked successfully in other parts of the world. As all the three types referred to are being installed in the grid, experience of the DVC in this respect will be of great value to others.

A statement showing the suppliers of major equipment for transmission system and substations is attached.

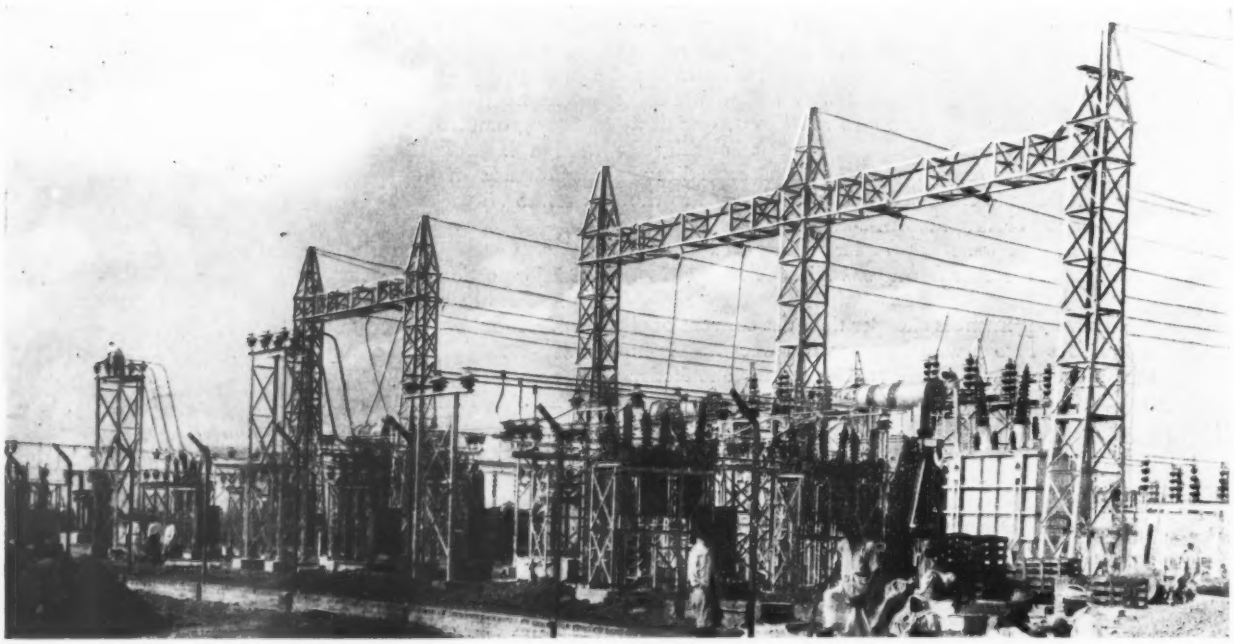
System Grounding

The 132 kV system will be solidly earthed through the neutral of the high voltage side of the transformer. This will provide adequate current to facilitate efficient operation of Earthfault relays and at the same time reduce the cost of the transformers. The 33 kV side of the step-down transformers are delta connected but the 33 kV system will also be grounded through a zig-zag connected Grounding transformer connected to the 33 kV bus. The latter is also to serve as a station service transformer at grid substations and because of its high impedence, inductive co-ordination of 33 kV distribution lines with the tele-communication lines under parallelism in the vicinity will cease to be a problem.

All equipment in the substation have two ground connections and are connected to the main substation grounding circuit, which in case of the grid substation is a grounding mat properly earthed at reasonable intervals.

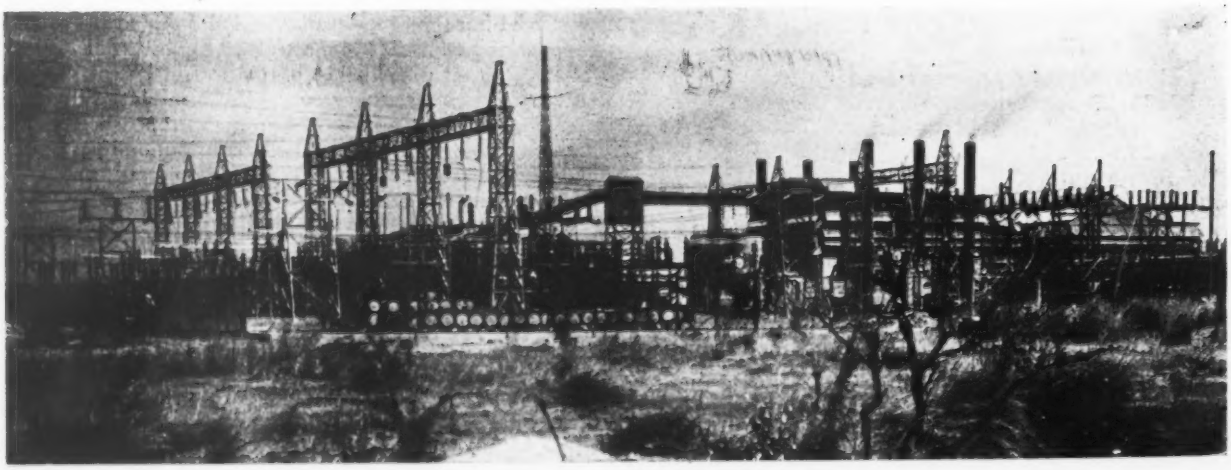
Relay Protection

The transmission lines and the substation equip-



Substation, Kalipahri.

Substation (facing east), Jamshedpur.



Substation at Sindri.

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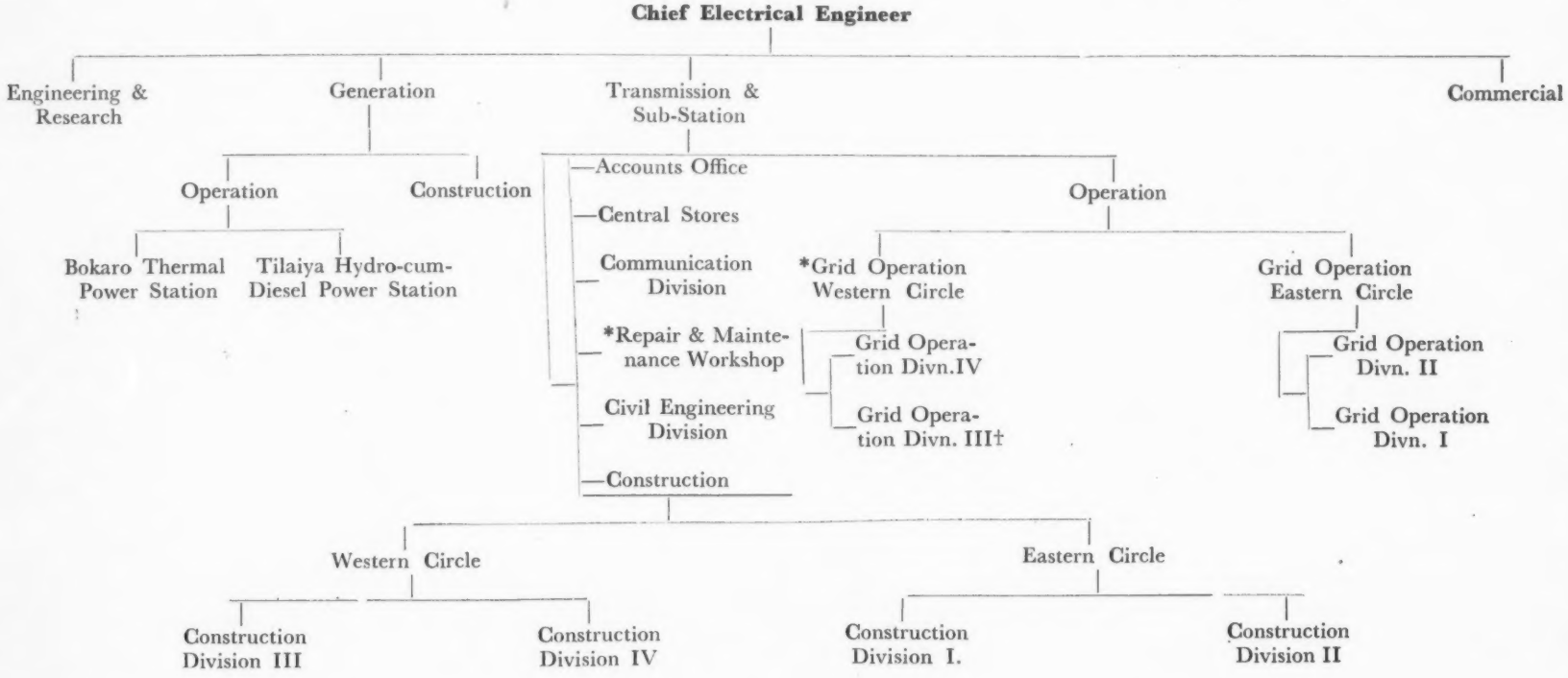
facing page 27

DVC Organisation Chart

March 1955



*Future Requirement
For the present Grid Operation
†Division III working under Eastern Circle.

ment will be provided with the following protective relays:

For Grid Transformers:

(*a*) Differential relay for circulating current protection with auxiliary relay to inter-trip the transformer breakers on the H.V. and L.V. side simultaneously.
(*b*) Inverse time-lag Overcurrent Backup protection.
(*c*) Buch-Holz double float gas detector relay for alarm and tripping.
(*d*) Alarm contacts with annunciator circuit for high temperature and low oil conditions.

For 132 kV, Transmission Double Circuit Lines:

(*a*) High speed impedance carrier current operated relay for phase to phase and phase to ground faults by three zone directional distance relays.
(*b*) In case of carrier failure, back-up protection by current polarised directional ground relay with time delay feature is provided.

For 132 kV Bus Bars:

(*a*) The transfer bus breaker is provided with over-current and earth leakage protection with inverse time characteristics.
(*b*) The bus is not at present provided with any protective relay. The station-type lightning arrestors and sky wires placed at correct shielding angle are provided.

For 33 kV Double Circuit Distribution Lines:

(*a*) At the sending end, parallel feeder protection for phase and ground faults with an auxiliary relay for preventing the healthy feeder from tripping out due to the additional load for one circuit remaining in outage.
(*b*) Over-current and earth leakage protection as a back-up to the parallel feeder protective relay.
(*c*) At the receiving end, directional overcurrent protection for the phase and ground faults.
(*d*) In addition to the above, an overcurrent relay operated by the totalised currents of two circuits in parallel is provided at the receiving end, as a back-up to the foregoing item (*c*) for fault current in both directions. In conjunction with this, an auxiliary relay is provided for group tripping of both breakers in case of faults on the 33 kV receiving bus.

Radio and Tele-communication System

It is recognised that to operate and maintain a grid power system spread over a large area like the Damodar Valley, an efficient and quick communication system should be installed in conjunction with the power transmission and distribution network. A "Central Load Despatching Station" will be located initially at Bokaro wherefrom control of power distribution to the various substations and also of power generation can be done quickly and reliably. For this purpose the following system has been proposed:

(*a*) Telephones operated by "High-frequency Carrier-Current" using the 132 kV line conductors in the grid, for inter-communication between the numerous substations, receiving stations and power stations channelled through the Control Engineer at the Central Load Despatching Station. For this, two high frequency channels for the duplex carrier current telephony has been provided for voice communication through the power line.
(*b*) To provide independent communication facilities when any section of the transmission lines for any substation is rendered out of service in an emergency, a radio-communication system with transmitting and receiving stations is designed for installation at the Central Load Despatching Stations, all substations and all power stations.

(*c*) For maintenance work and attending to break down locations in the grid, a "mobile petrol van", fitted with a VHF Transmitter and Receiver Set, will be provided to the power system operation engineers.

Construction

The construction of the 132 kV grid transmission and distribution lines and the installation work at the grid substations is being carried out departmentally. During the first year of construction, various preliminary works, viz: finalisation of transmission line routes, way-leaves and settlement of compensations, etc. have been carried out in addition. The team of erection engineers and technicians has now been organised and trained with mechanised erection appliances, some of which are being used for the first time in India.

Such major and heavy construction work as the DVC Power Transmission System has not been in the past undertaken for departmental construction; such work was carried out in India by specialist foreign firms. The DVC has undertaken departmental construction of these heavy works, as it would result in a considerable saving in the overall cost, and what is more important, provide an opportunity for training of Indian Engineers on this type of work.

Training Scheme

For execution of a large project like the DVC, men and material are needed. Trained Engineers and workmen are at present in short-supply. It was therefore necessary to send some men abroad for training in the installation and operation of high pressure, high temperature pulverisers fuel fired boilers, steam turbo generators and associated electric-

al equipment. Eleven men were thus sent to America for training in Plants similar to what is being installed in the DVC. In addition other men are also being sent for short periods for specialised training in construction and erection of electrical equipment. We also have a course of training in the organisation itself. Fresh graduates have been appointed and they are put through a course of 2 years in various branches, after which those who are found suitable are put in regular position depending of course on vacancies. So far this combined system of training has produced satisfactory results.

Major Equipment ordered for the D.V.C. Electrical Power Transmission System

Serial No.	*Equipment*	*Manufacturer*
1.	132 kV Transmission Towers	(*a*) Designed by Blaw-Knox Ltd. U.K. and fabricated by Richardson & Crudas, Bombay and Alcock Ashdown, Bombay. (*b*) Societa Anonima Elettrificazione, Italy. (*c*) Kamani Engg. Corporation Ltd., Bombay.
2.	33 kV Transmission Line Supports	Fabricated departmentally.
3.	A.C.S.R. Conductors & Ground Wire	(*a*) Aluminium Co. of Canada. (*b*) Aluminium Industries Ltd., Kundara, Travancore. (*c*) Furukawa Cable Co., Japan. (*d*) Hindusthan Electric Co. Ltd.
4.	Copperweld Groundwire and Earthing Electrodes.	Copperweld Steel Corporation, USA.
5.	Line Insulators and Station	(*a*) Locke Insulators Corporation, USA. (*b*) Nippon Gaishi Kaisha, Japan. (*c*) Steatite & Porcelain Co. Ltd., England.
6.	132 kV Circuit Breakers:	
	(*a*) Bulk Oil	British Thomson Houston Co. Ltd., U.K.
	(*b*) Poor Oil	Oerlikon Co., Switzerland.
	(*c*) Airblast	Brown Boveri & Co., Switzerland.
7.	33 kV Bulk Oil Circuit Breakers	(*a*) A. Reyrolle & Co. Ltd., U.K. (*b*) English Electric Co. Ltd., U.K.
8.	Power Transformers	(*a*) Hackbridge Hewettic Co. Ltd., U.K. (*b*) Ferranti Ltd., U.K. (*c*) British Thomson Houston Co. Ltd., U.K. (*d*) English Electric Co. Ltd., U.K. (*e*) A.S.E.A., Sweden. (*f*) Elin A. G., Austria. (*g*) A.E.G., West Germany.
9.	Control & Relay Panels	International General Electric Co. Ltd., USA.
10.	Metering Equipment	Landis & Gyr., Switzerland.
11.	Carrier Current Protection & Communication Equipment.	Brown Boveri Co., Switzerland.

(*Continued from page* 11)

Construction of Maithon and Panchet Projects

times before but should be reiterated repeatedly and that is that there is no substitute for experience. Each and every man from the Project Manager on down must know his particular duties and how to execute them. In the case of the Maithon concreting plant, as an example, the theoretical output of 4,000 cubic yards per day hinges on a great many operations being done in sequence and without interruption. The endless chain starts in the quarry. The requisite tonnage of rock must be quarried daily, crushed, screened and stock-piled for use. This requires the employment of experienced men at each of the critical points of operation such as drills, excavators, hauling units, crushers, conveying belts and screens. The batching plant, concrete transport trains and buckets, and concrete placing cranes must be kept in tip-top shape. Then at the dam-site the requisite space of placing the concrete must be available. Only then can the contemplated schedule be attained.

CANADA
FINLAND
U.S.A.
INDIA
ZEALAND
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TRANSFORMERS
F
FERRANTI
INDIA Five 3-phase transformers, three 20 MVA, 132/33-66 kV and two 10 MVA, 132/33 kV, have been supplied for the Damodar Valley Power Scheme.
NEW ZEALAND Twenty-six 220 kV single-phase transformers have been ordered by the State Hydro-Electric Department of New Zealand. Thirteen have already been supplied.
U.S.A. Of nine 33.3 MVA, 230 kV single-phase transformers being supplied to the U.S. Army Corps of Engineers for the Garrison Dam Project, N. Dakota, three have been shipped.
CANADA Four 300 kV, 71 MVA and three
transformers have been supplied to the
of Canada for the 'Alcan Project at
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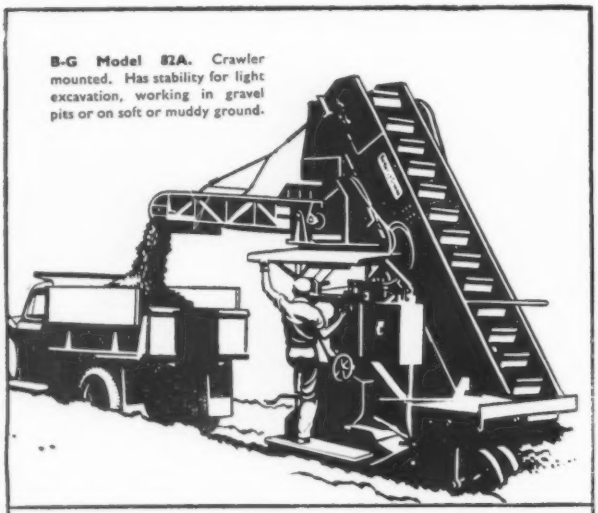
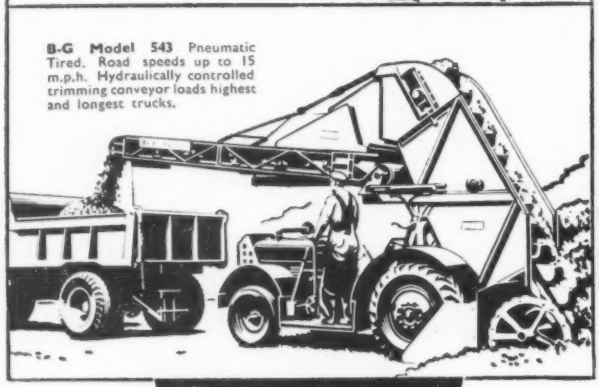


B-G Model 82A. Crawler mounted. Has stability for light excavation, working in gravel pits or on soft or muddy ground.



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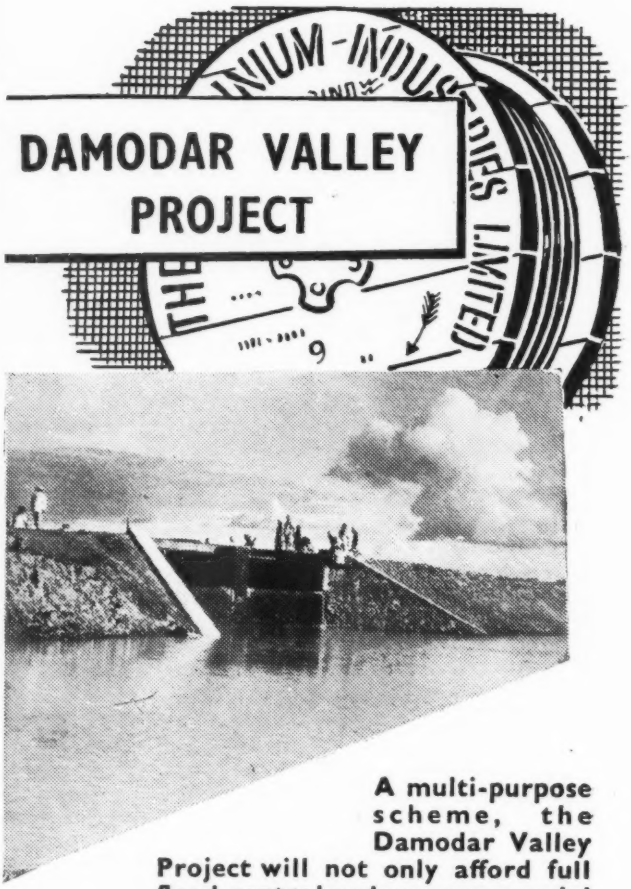

A multi-purpose scheme, the Damodar Valley Project will not only afford full flood control and assure perennial irrigation to the lower valley, but will also produce cheap electric power in abundant quantities. In the transmission of this electric power "Al-ind" Aluminium Cables play a notable part.

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(*Continued from page* 5)

Some Thoughts on the D. V. C.

either interest or profit, but not to both. That would be against all commercial principles. The Participating Governments should be either bankers or share holders; they cannot be both, and if bankers, they should get interest on their loan, and if shareholders, they should be entitled only to share the profits.

Again under section 34, it is provided that for a period not exceeding 15 years from the establishment of the Corporation, if the Corporation runs in deficit, the interest charges and all other expenses shall be added to the capital cost and all receipts shall be taken in reduction of such capital cost. This means that interest being capitalised, interest on interest has to be paid, leading to over-capitalisation. I contend that the Corporation should have been put on the same footing as other river valley projects, in order to have a proper financial appreciation of the D.V.C. Scheme vis-a-vis other projects. Again the cost of land debitable to the Project should have been only what is payable under the Land Acquisition Act and not all the expenses of rehabilitation and amenities to be provided to the displaced persons in implementing a national policy. The expenditure on flood control should be left out of calculation, because it means dividend to the people and not to the Corporation. I do contend that in order to have a realistic comparative picture of the financial returns, these considerations should apply. And I do submit once again that all the expenditure not directly allotable to power, irrigation and flood control should be met by a separate fund for which provision has been made under Section 32 of the D.V.C. Act. However, I finally submit that these schemes should be tested from the point of view of their wealth-producing capacity and not from their profit-earning capacity. If on an investment of Rs. 100 crores the D.V.C. produces wealth worth Rs. 30 crores annually, it should be considered to be a first-class scheme. But if you want to apply only financial standards, the yardstick should be the same for all projects.

These are some of the thoughts that have occurred to me in the course of the working of the D.V.C. Act. I do not propose to discuss in this article the costs and benefits of the Scheme. That will require another article. But I think an appraisal of benefits should be made by some specialist in that line, not only of the D.V.C., but of other river valley schemes.

The D.V.C., to my mind, represents an effort, however feeble, of man trying to control his environment and shape his destiny.

(*Continued from page* 8)

The Benefits of the Damodar Valley Project

ration is taking a keen interest in the increased use of power in small rural crafts. It has set up a team of experts for studying the possibilities in this direction. It has also started a few small industries in rural areas for demonstrating how some of the traditional crafts can be wedded to power with advantage. Though electrification of the rural areas is primarily the responsibility of the State Governments, the Corporation will do all that is possible with its limited resources to encourage the use of power by the villagers.

Other Benefits

The DVC Act authorises the Corporation to undertake several other functions for the development of the Damodar Valley. So far the Corporation has devoted its attention mostly to the three main objects, namely, flood control, irrigation and power. As the construction phase is coming to a close, more and more attention is being given to the other functions. Of these, the greatest importance attaches to the control of soil erosion in the upper valley. That soil erosion is fast growing into a serious problem in India, was known, until recently, only to a body of experts. Now there is a general realisation that India has been steadily losing some of her best top soil and that remedial measures must not be delayed any longer. The Corporation appreciated this problem from the beginning and has built up an efficient organisation for basic investigation, surveys and experiments. It is now taking up large conservation schemes. As most of the Upper Valley is well-populated and the land is mostly owned by small farmers, the soil conservation work has to be undertaken with the cooperation of the villagers. This is an arduous task as the farmer has to be convinced that it is worth his while to divert his labour and limited resources to this work. A band of trained men are now working with the villagers and are trying to raise their enthusiasm by demonstration schemes subsidized by the Corporation. These and many other welfare measures are the responsibility of the Corporation according to the Act. But all these will cost money. The Act has not given the Corporation any appreciable source of revenue. It has to get the funds from the three Participating Governments, namely, West Bengal, Bihar and the Central Government. The welfare and general development activities of the Corporation are therefore limited to the extent to which it is given funds for such work.

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PSMF 2

Panchet Hill Project

A. L. DAS

Additional Chief Engineer, Damodar Valley Corporation

AUTHOR

The river Damodar rises in Chotanagpur Hills at an elevation of about 2000 ft. and flowing through Hazaribagh and Manbhum District of Bihar for a distant of about 180 miles, enters West Bengal. The river flows through Bankura, Burdwan, Hooghly and Howrah Districts for about 160 miles and joins Hooghly 30 miles below Calcutta. The total drainage area is 8500 square miles of which 6960 miles lie above the confluence with Barakar the principal tributary.

The Damodar is known for its flood damages. Plans to control the Damodar have been considered since 1850. The floods of 1913, 1935, 1941 and 1953 were particularly severe. The flood of 1943 is still fresh in public memory. After the 1943 flood, a Flood Enquiry Committee was set up and the Central Technical Power Board of Government of India drew up plans for Flood Control and Water Resource Development for multiple purposes on the lines of the T.V.A. The Damodar Valley Corporation was set up in July 1948 and was entrusted with the task of detailed designs and construction.

Panchet Hill Project and Major Features

All the dams proposed in the Scheme are sited above the confluence of the Barakar with the Main Damodar. Panchet, the last dam on the Damodar, is 3 miles above the confluence and 13 miles west of Asansol The drainage area of the Damodar at the dam site is 4234 sq. miles. The height of the dam above river bed is 133 ft. The reservoir behind it provides a controlled storage capacity of 1.214 million acre ft. A hydel plant of 40,000 kW is to be installed initially, with provision for a similar second set at a later date.

Flood Control

Panchet dam along with the Maithon dam, both located a few miles above the confluence of the Barakar with the Damodar are nearest to the area exposed to flood danger and are therefore most suitable for flood control. The storages provided at Panchet are 1,48,000 acre-ft. for dead storage 1,85,000 acre-ft. for irrigation and power and 8,81,000 acre-ft. for flood control. 15 radial gates 41′ width × 40′ height have been provided with top of gates at E1.445. The discharging capacity at E1.445 is 5,85,000 cusecs. The undersluices 10 Nos. 5′-8″ width × 10′-0″ height provide further capacity of 30,000 cusecs at normal Pool E1.410.

Irrigation

The storage available at Panchet Hill dam along with the storage available at Maithon Dam will assure irrigation for one million acre of kharif and 3,00,000 acres of rabi in West Bengal.

Power

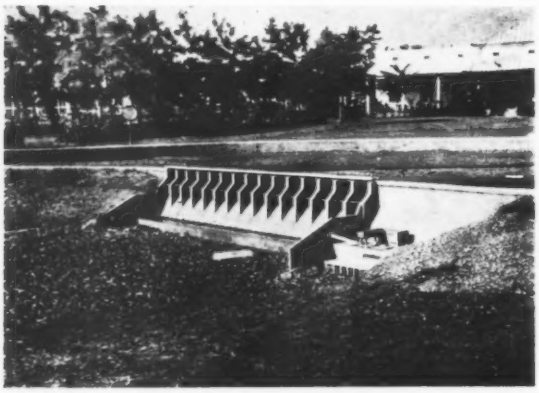
Initially one 40,000 kW generating plant will be constructed with a provision for an additional 40,000 kW plant at a later date. Average annual hydroelectric energy that can be generated is estimated at 152 million kWhrs. The normal rated head is 85 ft. The usual maximum head is 120 ft. and minimum head 67 ft.

Topography and Geology of the Site

The river bed at the site is about 1600 ft. wide and is at an elevation of 323. The right bank rises to 130 ft. above the river bed in about 3300 ft. Thereafter the alignment runs firstly through a hillock and then across a saddle of about 1850 ft. length and dropping to about 110 ft. above the river bed at its lowest point before finally tying up with the higher ground. The left bank rises to 130 ft. above the river bed in a distance of about 5300 ft. The alignment then runs through almost level ground for a distance of 4100 ft. and thereafter along a saddle of about 3,450 ft. and about 115 ft. above the river bed at the lowest point before rejoining the higher ground.

The site of the dam (23°41′N 86°46′E) lies at the western fringe of Raniganj coalfields. The site is easily accessible, well-connected by roads and railways. The nearest railway stations are Barakar and Kumardhubi. A 6 mile metalled road connects the dam site with the G. T. Road at mile 149 from Calcutta.

The exposed rocks on left bank and first 6,200 ft. of alignment on right bank are garnetiferous and micaceous augean gneisses having a NW-SE strike with steep dips to the N. E. The underlying rocks in the river bed are also garnetiferous and micaceous augean gneisses. The rest of the alignment on the



Model of Panchet Hill dam.

right bank is composed of Barakar stage, Ironstone shales and Raniganj stage.

No less than five alignments were examined before the present one was finally selected. The geology and subsurface conditions of the site have been fully investigated by numerous drill holes in the spillway and power house area and across the river channel. In the river channel there is an overburden of alluvium sand and fine gravel averaging about 50 ft. in depth. In the spillway and power house area on the left side of the river, there is an overburden of about 10 ft. of soil, then 20' to 40' weathered rock resting on sand gneiss or schist. A few dormant faults have been noticed but these are sufficiently tight and are not apt to cause any adverse consequences. Examination of drill cores reveals adequate density and hardness of the fresh rock to support the weight of the dam. The alluvium in the river channel is considered suitable for the foundation of the earth embankment.

Hydrology

The available records of rainfall of the area cover about 60 years. The network of raingauges has been extended to 51 stations. Th average annual rainfall is 47" varying from a maximum of 64" to a minimum of 31". About 85% to 90% of the rainfall occurs during the period June to October.

Stream flow measurements have been made regularly at the Anderson Weir (Rhondia), since its completion in 1932. The total drainage area at Rhondia is 7,690 sq. miles. The Rhondia record shows that annual runoff varies from a maximum of 31" to a minimum of 10" with an average of 20". In an average year 90% of the the annual flow occurs during the monsoon from June to October. A peakflow of 6,40,000 cusecs was observed at Rhondia in August 1935 and again in October 1941.

The design flood of Panchet is based on a rainfall of 23.5" derived from area-depth curve for the design storm. Assuming a runoff coefficient of 90%, the runoff for the design flow at Panchet Hill dam is estimated to be 21.15". Assuming 1½ times Inglis flood as applicable, the peakflow of design flood is estimated at 6,82,000 cusecs. Design flood hydrograph constructed on the basis of duration of flood at Rhondia is used for design of spillway capacity and flood routing. The inflow hydrograph has following characteristics.

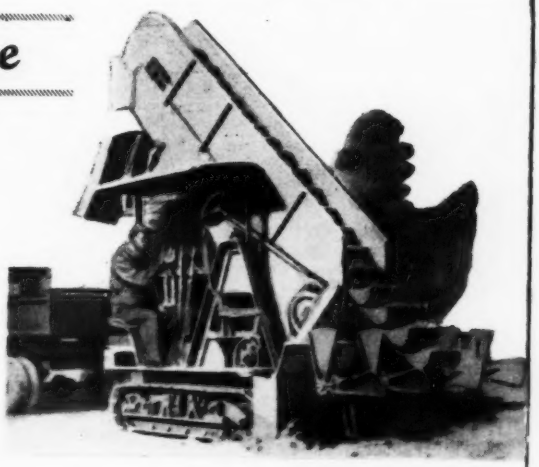
Peakflow	..	6,82,000 cusecs
Runoff	..	21.15 inches
Totalling	..	4780,000 Acre ft.
Duration	..	8 days
Period of rise	..	2.2/3 days
Priod of fall	..	5.1/3 days

Provision is made in the layout to discharge 5,85,000 cusecs over the spillway (15 spans 41' width × 40' height) and 30,000 cusecs through the undersluices (10 Nos. 5'-8" width × 10' height). The total outflow capacity equals to 6,15,000 cusecs. Routing of design flood under these conditions gives a maximum flood stage of El. 446.7. The dam has been designed for a maximum headwater level of El. 449.0 at which level the combined discharge of spillway and underluice openings is 7,12,000 cusecs.

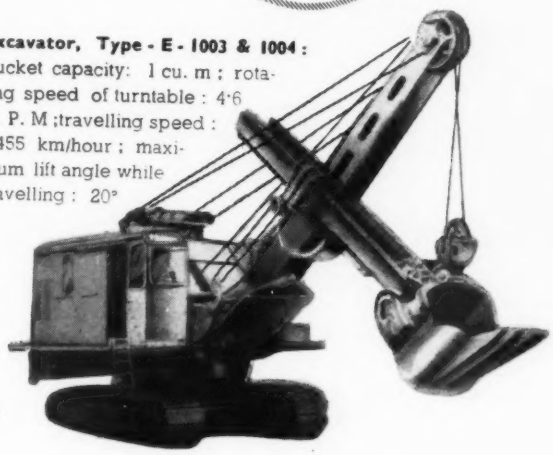
An evaluation of the relative significance of various flood frequencies is important. This is, however, not very reliable as the flood data cover too short a period of two decades. It, however, serves as qualitative index and is tabulated below :—

Flood hydrograph Frequency — years	Storm rainfall of Rhondia catch- inches	Storm Rainfall —Panchet Hill — Catchment		Flood Hydrograph-Panchet Hill		
		Inches	Duration — Days	Runoff 90%	Peak flow cusecs	Duration (Storm duration 12 days)
90,000	20.0	23.5	6.5	21.1	690,000	8.0
14,000	17.0	20.0	6.0	18.0	620,000	7.5
4,000	15.0	17.6	5.6	15.8	570,000	7.1
600	12.0	14.1	5.0	12.7	500,000	6.5
180	10.9	11.7	4.6	10.5	450,000	6.1
35	7.0	8.2	3.8	7.4	360,000	5.3
1.5	2.0	2.4	2.0	2.2	130,000	3.5

Quality *Service*



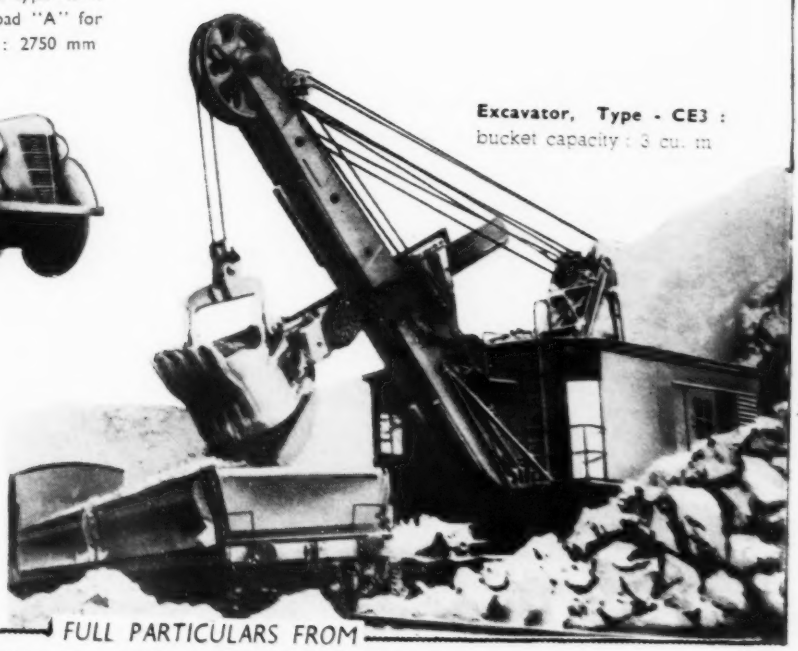
Excavator, Type - E - 1003 & 1004 : bucket capacity: 1 cu. m ; rotating speed of turntable : 4·6 R. P. M ;travelling speed : 1·455 km/hour ; maximum lift angle while travelling : 20°



Self - Propelled Elevating Loader, Type - T - 61 : max. lump size of loaded material : 100 mm ; working width of the special conveyer : 2· 5 m; travelling speed with the spiral conveyer ahead: 0· 19 and 1· 4 km/hour ; capacity : 100 cu. m/hour

Storage Battery Autoloader, Type-O2 & O4 : load capacity for type - O2 : 1· 5 t & type - O4 : 1· 5 t; max. height with hoisted load "A" for type - O2 : 4000 mm & type - O4 : 2750 mm

Excavator, Type - CE3 : bucket capacity : 3 cu. m



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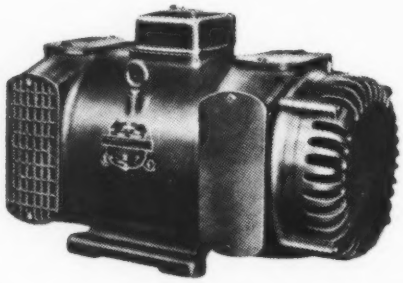

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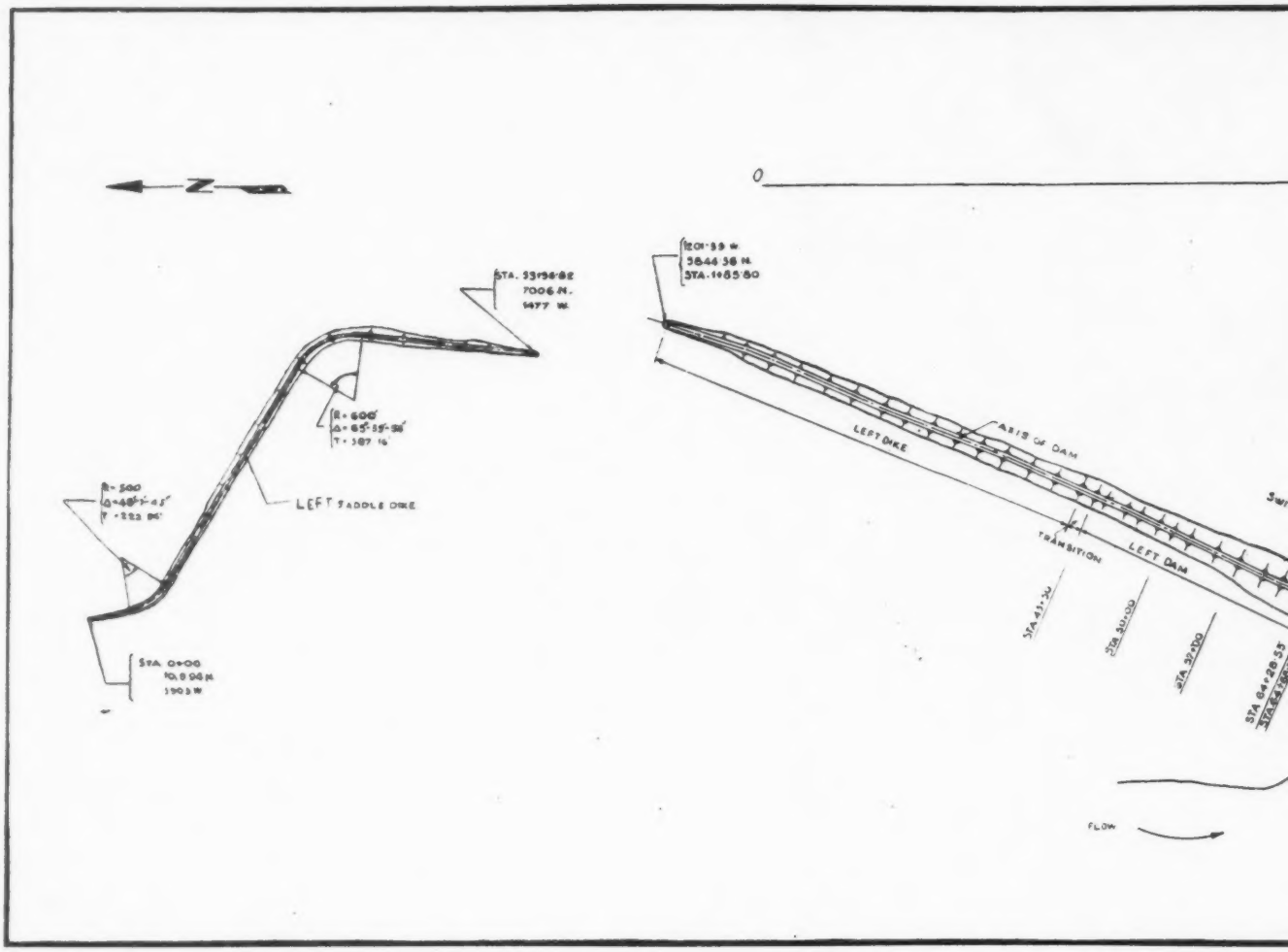
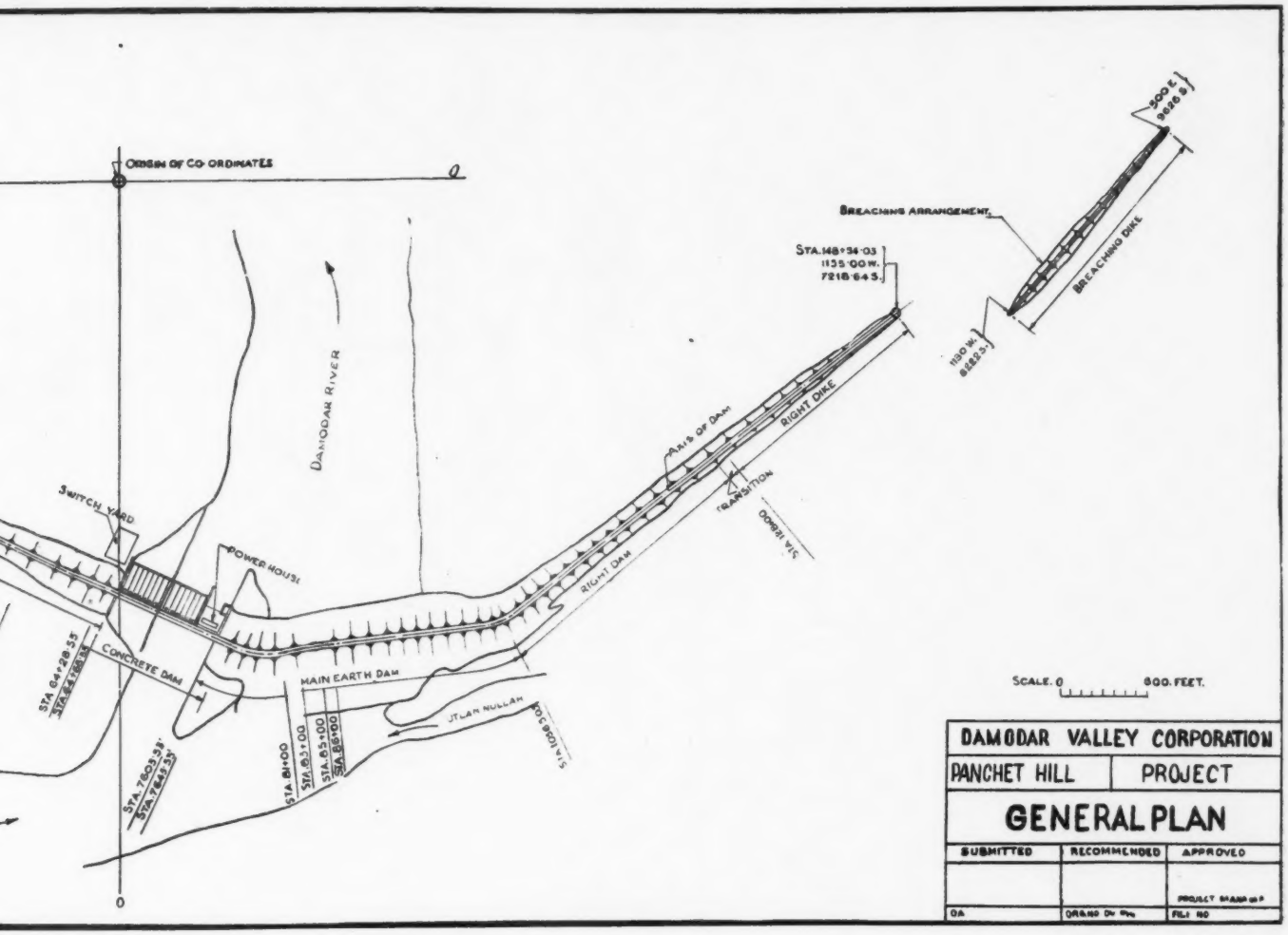

N
STA. 53+94·82
7006 M.
1477 W.
R = 600'
Δ = 65°-55'-58"
T = 387·16
R = 500
Δ = 48°-1'-45"
T = 223·86'
LEFT SADDLE DIKE
STA 0+00
10,898 M
1903 W
0
1201·39 W
3844·36 N.
STA. 1+85·80
AXIS OF DAM
LEFT DIKE
TRANSITION
LEFT DAM
STA 31+30
STA 30+00
STA 32+00
STA 64+28·53
FLOW

Facing Page 32



Constructional features of the Project

The main works may be classified under two distinct heads (i) Dam and Appurtenant works (ii) Hydro-electric installation.

The Dam and Appurtenant works consist of Earth Dam resting on alluvium across the main river extending to some lenth on both banks, earth dykes, saddle dyke, breaching dyke, diversion channel, a concrete spillway across the diversion channel abutting on concrete bulkheads at the two ends.

Hydroelectric installation consists of Power House structure Intake, Water-conductors, Sub-station Yard and Installation of equipment.

The Project includes the following main items of work :—

A. *Excavation of common soil*		
(1) Diversion channel	6,50,000	cu.yds.
(2) Earthdam foundation	1,58,100	,,
(3) Earth dam Borrow	47,28,400	,,
(4) Dykes foundations	1,11,800	,,
(5) Dykes Borrow	12,35,800	,,
(6) Concrete dam	1,92,400	,,
(7) Power House	8,610	,,
	70,85,110	cu.yds.
B. *Excavation Rock*		
(1) Diversion channel	6,60,000	cu.yds.
(2) Borrow for earth dam	45,000	,,
(3) Borrow for dykes	15,000	,,
(4) Concrete dam	4,16,920	,,
(5) Power House	87,615	,,
(6) Quarried rock for concrete aggregate	2,50,000	,,
	14,74,535	cu.yds.
C. *Embankment*		
(1) Earth Dam—Rolled fill	53,44,000	cu.yds.
(2) Earth Dam—Rock fill	4,37,900	,,
(3) Dyke Rolled fill	11,23,460	,,
(4) Dyke Rock fill	85,720	,,
	69,91,080	cu.yds.
D. *Cement Concrete*		
(1) Abutment	1,20,850	cu.yds.
(2) Retaining wall	28,500	,,
(3) Stilling Basin	62,550	,,
(4) Spillway	1,48,660	,,
(5) Power House	63,905	,,
	4,24,465	cu.yds.

Salient features of the Project

River Basin

Drainage area at dam site	4,234	sq. miles
Maximum flow (at Sudamidh Bridge 20 miles upstream)		
Record from 1946 to date	3,02,000	cusecs in 1950
Drainage area at Sudamdih	3,408	sq. miles

Dam

Height above river bed to roadway level (El 457—El 324)	133	ft.

Length

Concrete spillway	765	ft.
Bulkhead (left)	127.5	ft.
Bulkhead (right)	322.5	ft.
Earth dam (main)	7235	ft.
Earth dyke (left)	4114	ft.
Earth dyke (right)	2104	ft.
Breaching dyke (right)	2151	ft.
Saddle dyke (left)	5337	ft.
	22156	ft.
or 4.2 miles.		

Width

Maximum at base of spillway	96	ft.
Including stilling Pool	250	ft.
Main Earth dam	800	ft.

Spillway

Number of Sluice gates	10
Number of Crest gates	15

Reservoir

Area submerged El 425	35.6	sq. miles
Length (Back-water)	26	river miles

Storage volume

Total at El. 445.0	1,214,000	acre ft.
Controlled flood storage El 410 to El 445	881,000	acre ft.
Low water release at El 410 to El 392	185,000	acre ft.
At max. draw-down El 392	148,000	acre ft.

Power Plant

Installed capacity	40,000 K.W.

Head

Maximum	120 ft.
Minimum	67 ft.
Normal	85 ft.

Construction Procedure

All the main items of work are being done departmentally with mechanical equipment. For the earth dam, the procedure of work followed is that the original ground surface is tripped to depth of 2 ft. Selected soil from borrow areas is excavated by means of power excavators, loaded into dumpers, hauled to site of work and unloaded at intervals over a definite zone according to quality of material required for the same. The dumped material is then spread out as level as possible and finally dressed off in 8″ layers

with a motor grader. The surface is then scarified by means of disc harrows and watered by means of water trucks to bring the water content in the soil to predetermined optimum value. The layer is then scarified thoroughly to get th soil mixed up with water. Then the layer is finally rolled to compaction with sheeps foot rollers producing pressure not less than 500 lbs sq. in. when the surface is tested for compaction and density and passed, the the second layer is spread over it. The sorting out of the soil for different zones is done by the control wing and every dumper after loading is flagged with the mark of the zone in which it is to be used. Similarly the different zones in the section of the dam are marked by flags of colours corresponding to those in the borrow area, to enable the operators to place the soil contents in its proper zone. Proper control is also exercised on the quantity of water used. Test samples are taken at one per 1000 cu. yd. of earth fill after compaction by sheeps-foot roller.

The salient details of each type of fill are as under:

Location	*Impervious Soil average*	*Semipervious soil average*	*Homogenous average*
	Core	*Ch. 54-61*	*Ch. 54-61*
Borrow Source	Sector 1	Sector 1	Sector 1
O.M.C. of dry soil	15.2	14.6	15.0
Dry density lbs/cft.	114.4	112.4	110.0
Moisture after rolling	11.7	10.6	11.3
No. of roller passes	12	12	12
Rolld density lbs/cft.	115.2	106.7	105.2
Degree of compaction as % of Lab. density	100.7	94.7	95.1
Neddle Resistance lbs/sq. after rolling			
Top	540	585	700
bottom	630	630	750

Concrete work

For the purpose of mixing concrete there are two numbers of two cubic yard batching plants with automatic measuring devices. Each of the batching plants is fitted with two numbers of bucket type elevators for lifting aggregates and cement to the bin at top. Cement is fed into a hopper at bottom, from where this is propelled forward by means of a screw arrangement into the buckets of the elevator which lifts cement to the bin at top. Sand and small aggregate are discharged into a hopper fitted with a sliding door at its junction with elevator buckets. For carrying larger size aggregate a conveyor belt has been fixed. At the lower end, it is connected to a hopper and at the other end, it discharges into the bins on the top of the batching plants by means of a rotating chute. The discharge end of the conveyor belt is 60 ft. above ground and the slope of the belt is 18° to the horizontal.

After mixing, the concrete is discharged from the mixers through a chute into one cubic yard buckets placed on trolleys which are pulled on rails by diesel engines to the concreting site. The buckets are then lifted by cranes and concrete placed inside the formwork. Concrete is placed in four-feet lifts. The time interval between each lift is specified at 72 hours. Water-stop-metal (copper strips) is placed near the upstream face. The concrete after placing is vibrated with pneumatic vibrators 4″ size having a frequency of 3000 to 3500 per min. Vibration enables the use of larger size aggregate upto 6″ size, reduction in cement content per mix and in the quantity of water. The mix is altered from time to time to suit size of aggregate used and to conform to specified workability. Test cylinders are taken at one set (3 Nos.) for every 300 cubic yards of class A and B concrete and one set for every 50 cubic yards of class C & D concrete and these are moulded, cured and tested in accordance with standard methods. Some of the test results are given below:—

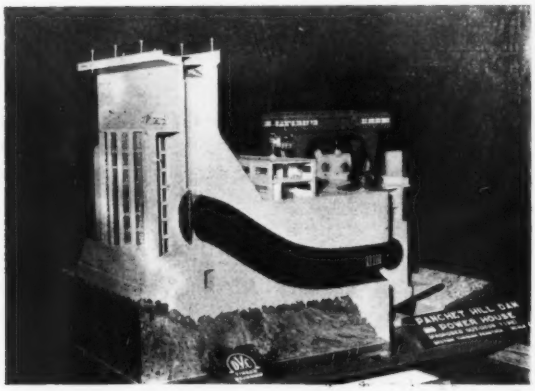
Mix type	A_1	A_2	B_2
Aggregate	2070 lbs 3″-	2200 lbs 3″-	2230 lbs
	800 ,, 1″-	500 ,,	560 ,,
Sand	900 ,,	820 ,,	880 ,,
Cement	400 ,,	350 ,,	450 ,,
Water cement ratio (by weight)	0.61	0.60	0.52
Slump (inch)	2″	1″	3/4″
Compressive strength (P.S.I.) (6″×12″)			
7 days	2180 lbs.		2070 lbs.
20 days	2480		
60 days	3270		
70 days	4840		3900 lbs.

More test results for concrete are not available as concreting work has been taken up only lately.

Design

Design of the dam has been done by the Harza Engineering Company of Chicago, who are the Consulting Engineers to the Corporation, having their local office at Maithon in charge of a Resisdent Engineer.

Normal practice in this type of Flood Control dam is to locate the spillway across the main stream, but in the case of the Panchet Hill dam, the spillway has been placed across a diversion channel cut across a ledge in the left bank. This has been done as bed-rock for foundation of spillway is obtainable at a much higher level (312 R.L.), whereas rock in the river bed is more than 50 ft. below the over-burden at (R. L. 270).



Model of Panchet Hill Powerhouse.

Hence provision of a diversion channel for location of the spillway is justified on economic considerations. Moreover, most of the spoil from the diversion channel can be utilised in the dam-fill. Bed of the divrsion channel has been kept at 330 R.L. for the right half and 340 R.L. for the left half. Approximate size of the channel is 600 ft. wide by 2,700 ft. long.

Earth dam

This consists of rolled-fill earth. Embankment with rolled-fill earth has been chosen, as suitable materials are available at site within a maximum lead of $2\frac{1}{4}$ miles. The top width of the dam is 35 feet at elevation 457. This consists of two zones, the core consisting of impervious material and shoulder fill on both sides with semipervious material. The impervious zone rests on a clay blanket which extends to average 580′ upstream and 220′ downstream from the centre line of the dam and limited to the bed portion of the main river.

In the remaining width, the earth dam rests on natural alluvium and no special foundation has been provided. The impervious zone slopes out from top at a slope of 1 vertical to 0.35 horizontal to a plane 32 feet average from the base where it slopes out at 1 vertical to 20 horizontal on the upstream side, till the height of fill above base is 8 ft. where it slopes out to bed at 1 vertical to 3 horizontal. On the downstream side the core line slopes down at 1 vertical to 20 horz. to a point where the height of fill is 20 ft. above base, when it slopes off at 1 vertical to 1.4 horizontal.

The upstream shoulder fill starts at a point 17.5 ft. from the dam axis at top and slopes down at 1 vert. to 3 horz. till it meets the blanket.

Earth Dam on Bank

This is of similar section as that on the river bed excepting that the entire base is stripped to a depth of 2′, a key-trench of 5 feet minimum depth extending to 0.35 height + 15 feet on either side of the axis is provided and there is no blanket or cut-off wall. The impervious core commences from the edge of

Earth dam, Panchet Hill.

key-trench and slopes inward with 1 vert. to 0.35 horz. upto the top.

Bank protection

The upstream face of the shoulder fill is provided with a layer of 10″ thick crushed rock from top to 377 R.L. overlaid with a layer of placed rock 18″ thick upto R.L. 427.09, where the thickness of placed rock is increased to 3 ft. upto the foot of the shoulder fill.

Rock Filter

The downstream toe of the dam is provided with a rock filter which commences from 368.5 R.L. and extends to bed level to help efficient drainage. The top of the filter forms a roadway 35′-0″ wide. The outside face of the filter slopes down at 1 vert. to 2.25 horz. The portion of the downstream face above the filter will be covered with sodding.

Cut Off

The cut-off is located on a line parallel to the axis of the dam and 20′—0″ upstream. This consists of a single row of Larsen Sheet Pile wall driven to bedrock. The top of the piles extends 20 ft. into the impervious core.

Spillway

The spillway will be a concrete structure with 15 crest gates and 10 undersluices. Its upstream face will be vertical and downstream face will follow a curve of the shape of nappe of the overflow ending in a stilling pool or bucket. The centre line of undersluices shall be at El 342 the crest gates still at El 405 and the top of the gates at El 445. The crest gates will be of radial type having a travel of 63°30′, with the trunion axis at 422 R.L. Provision has been made for drainage and operation gallerries.

Energy Dissipating arrangement

The choice lays between bucket type and hearth type. As a result of model experiments and examination of site bucket type dissipator has been adopted.

Specification for materials

Impervious soil

The soil shall be free from all organic and vegetable matter and have a coefficient of permeability generally below 10 ft. per annum under standard Proctor Compaction and not more than 20% of random samples for core material should show a permeability between 10 ft. and 50 ft. per annum and not more than 1% of such samples shall have a permeability of more than 50 ft. per annum.

Semiperusious Soil

The semipervious soil for shoulder fill shall be coarse granular soil or weathered rock, somewhat sandy iu look as well as fill and may contain fragt mented rock pieces. Permeability should be highe-than 50 ft. per annum for at least 80% of the shoulder fill quantity and impervious soil shoulh be strictly avoided. Of the shoulder fill material, the "coarse" material should be placed on the inner side and the very coarse on the outer side.

Crushed Rock and Placed Rock

These shall be obtained from hard and clear fresh rock collected either from quarry or excavation in the diversion channel or concrete dam foundations. Crushed rock shall have maximum size not larger than 5″ and may be either hand broken or crusher run The minimum size for placed rock shall be 12″.

Rock Filter

This should consist of three layers. The bottom two layers shall extend along the bed to a height 5 ft. from the base on the downstream slope of shoulder. The layer in contact with the bed shall be 18″ thick and shall be formed with 19″ thick crushed stone well graded from $\frac{1}{4}$″ to 1″. The intermediate layer shall be 18″ thick and shall be composed of 1″ to 3″-4″ thick, 3″ to 6″-6″ thick, 6″ to 8″-8″ thick layers with coarser layer towards rock fill. Above 5 ft. from bottom upto 370 R.L., the downstream slop shoulder fill shall be covered with a 3′-0″ thick laye of rock, not larger than 12″ nor smaller than 2″ graded with coarser materials nearer and finer materials away from dumped rock. Over this, will be laid dumped rock 15.06 ft. thick finished to a slope of 1 vert. to 2.25 horz. with a minimum thickness of 5′ towards the outer end. The rock fill shall be composed of boulders of minimum 12″ size, with atleast 50%, but not more than 80%, smaller than 30″.

Cement Concrete

The aggregates and cement to be used for concrete shall conform to recognised standard specification. Four different classes of concrete have been specified for the concrete dam :

Class of concrete	A.	B.	C.	D.
Minimum strength at 28 days-lbs/sq.in.	2200	3000	3000	3000
Maximum size of aggregate	6″	2½″	1½″	3/4″

Principal uses for the different classes of concrete are Class A for general mass concrete in the dam ; Class B within 5 feet of the faces of the dam : Class C for general structural concrete ; Class D for special details where difficulties in placing or other conditions may call for a more workable mix.

Construction Porgramme

This Project being a part of the integrated plan of development of the Valley, the construction programme has been so planned that with the tempo of operation at other Project decreasing, the equipment likely to be surplus there would be transferred to this Project ; thus lessening the financial commitments for procurement of equipment. Also the programme of work has been adjusted in such a way that less engineering attention will be required during the the first working season for the main dam work and

[*Coniinued on page* 57

Personnel Policy of the D. V. C.

By
SOHAN LAL
Director of Personnel, Damodar Valley Corporation.

AUTHOR

People have often asked, what the personnel policy of the DVC is. It is not a matter which can be described in a few words. But precisely, the basic conception of the policy has been 'merit'. Having said this, there follows a series of other questions—how we assess merit, does not that lay us open to charge of favouritism (if not nepotism), are we not giving overemphasis of a particular criteria, and so on! A brief account of the personnel administration in the DVC will perhaps meet the queries and be of interest too.

There are two aspects of personnel administration—psychological and material. On one side, it should be able to present fair and equal chances to all for the fulfilment of human aspirations. On the material side, it should be able to secure the efficient outturn of human efforts. One is, however, dependent on the other—it is a complex circle. I do not know of any organisation where, in both these spheres of human employment, perfection has been reached. Everywhere it is in a state of continuous adjustment, circumstanced by the changes in technological, economical, social and political fields. The personnel policy of the DVC too has not been free from the influence of such factors.

Centralisation of Personnel Administration

In DVC the control over personnel policies and methods and performance of personnel service have been concentrated in a Central Personnel Department. This was perhaps inevitable, if uniformity in the application of the policies were to be ensured. Many of the engineering and administrative officials of the Corporation, who were drawn from the different engineering fields and other branches of private employment, having different traditions, regarded the system as too much of centralisation. There was a feeling among the engineers, and it is even today in certain quarters, that they were being bound in red tape and subjected to delays and controls by the Personnel Department who do not understand their problems or talk their language. But eventually there has been the general recognition of the necessity for a basic system to ensure, if not equality of treatment, which is perhaps exactly unattainable, an equity of treatment.

Recruitment

The most important feature conditioning the personnel problem in the DVC has been the fact that the Corporation was to set up an establishment, practically from scratch all at once, involving not only engineers of all grades and types, mechanical, electrical, civil and specialists, but also soil scientists, planners and designers, erectors, mechanics, operators, besides administrative and secretariat men, accounts, doctors, clerks and technicians of all grades plus an adequate purchasing organisation. Practically DVC's personnel problem was in no way less than that of a minor local government with complications far more wide.

It is better also to emphasize here certain handicaps from which the DVC had to suffer from its very inception. This is a project which operates in Bihar and West Bengal. Naturally, the people of these two States claim preference in employment. On the other hand, merit as assessed by an impartial body has to be taken care of, irrespective of geographical or political considerations. At the same time, the Corporation, charged with the responsibility of developing the valley, cannot also overlook the special claims of the people of the valley, particularly those whose land had to be taken over. There were also the displaced persons from Pakistan who under the directives of the Government require to be treated in a generous way as a part of the national policy.

Keeping all these considerations in view, the Corporation's attempt has been to select the most suitable. All important vacancies are notified in papers. Other positions are either advertised and/or notified to Technical Institutions, Universities and Employment Exchanges. Selections are made on open competition.

There is one point on which there has been some amount of public criticism and that is with regard to appointment of foreign experts. Considering the overall paucity of technical personnel throughout the

country and the need for an expert organisation which could train up Indian personnel adequately, Corporation at its initial stage had to appoint a few foreign experts in its different Engineering Sections, like planning and design, construction, soil conservation, etc.

Merit Service and Personnel Rating

In Government service, perhaps the traditional practice of promotion on seniority basis has a more decided bias than a pure assessment of merit. DVC, from the very beginning, has tried to evaluate all conditions equally and equitably with the result that merit counts, as it should, much more than other considerations. In a way this is more important in an organisation which does not cater for a 30-year service but only 3.

DVC has also introduced another system which should prove an incentive for good work. Advance increments are granted within the pay scales on merit basis, with the result that an employee can look forward for higher pay, outside the usual turn of annual increment, if he does really good and meritorious work.

Training

One of the main handicaps the Corporation experienced at the initial stages was the paucity of the right type of men required for its multifarious works. This was, however, natural, for the Corporation had embarked on a pattern of work which was new in the country. Whatever personnel were available, their experience and training were different. But the adaptability of the Indian engineers and technicians in this respect has been found most remarkable.

To effect quick adjustment, training in foreign countries and within the DVC has been arranged. Soon after the Corporation came into existence, a group of engineers was sent to the United States to gain experience in erection, maintenance and operation of thermal power plants. These engineers are today manning the Bokaro Thermal Power Station, which is regarded as the only of its kind and biggest in India.

Under agreement with the suppliers of electrical equipments, arrangement has been made for the training of DVC engineers at the manufacturers' works in Europe and England on a paid-by-firm basis. A good number of engineers have been trained under this arrangement. The Corporation has also taken advantage of the different technical assistance schemes. A few engineers have been trained in the different spheres of specialised engineering in the United States and the United Kingdom, under these schemes.

Under training-within-DVC schemes, junior engineers, overseers, technicians, mechanics and accountants are given training to become productive in the shortest possible time.

For the displaced persons of the submerged areas, there exists a special arrangement for training. Young displaced persons with aptitude for mechanical work are selected and given a year's training as mechanics and operatives. They are paid a subsistence allowance during the training period. After training they are employed as they are fit for.

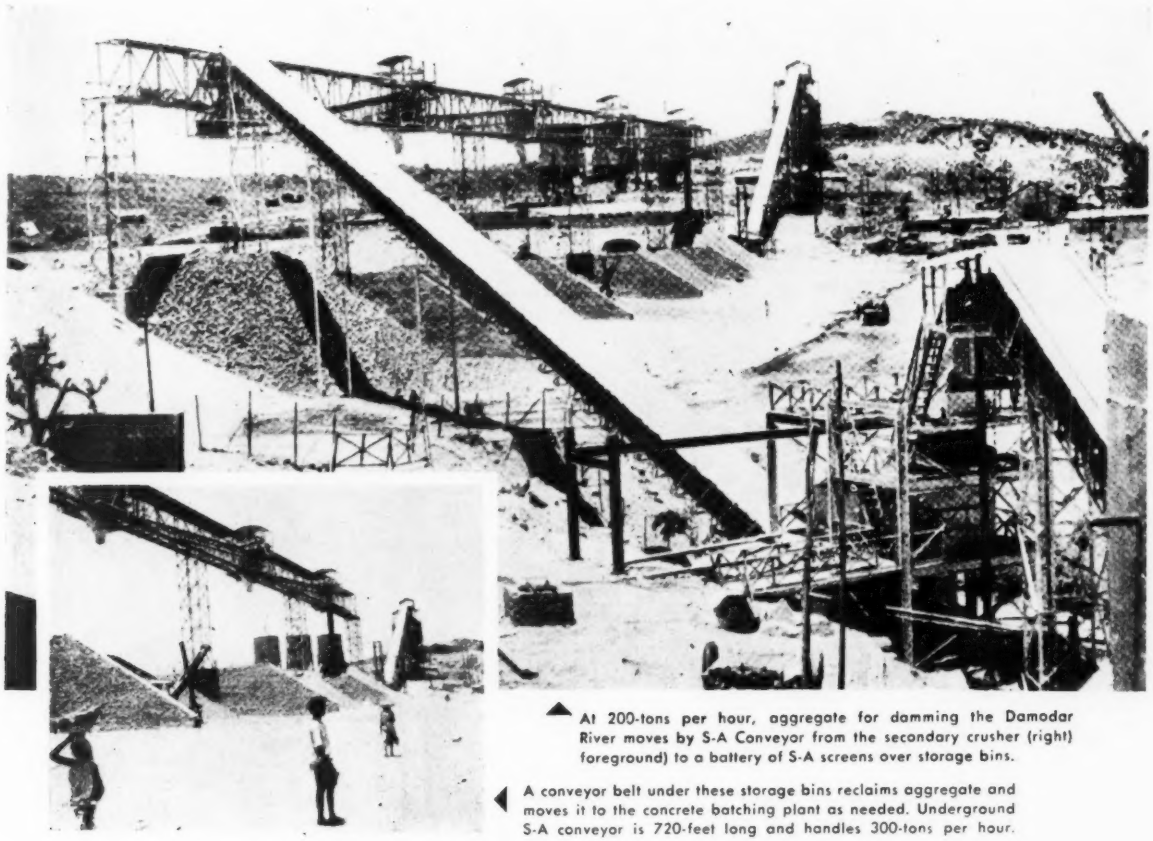
Besides the above training schemes, meant to meet Corporation's own requirements, facilities of practical training have been extended to fresh engineering graduates and under-graduates of the country. They are not paid any stipend or allowance by the DVC. In this matter, the Corporation works in close collaboration with the Ministry of Education of the Government of India and the Engineering Institutions and Universities of the Participating States. Many foreign nationals have also received training in the Damodar Valley Corporation.

Welfare and Employee Relation

As is natural in a river valley project, the Corporation had to start its work in the upper reaches of the valley, and these were outside the communication lines. Soon after the preliminary investigations were over and the sites for construction located, small townships were set up and connections with the existing highways established. One of the first tasks of the Corporation was to provide the essential amenities of civic life, such as, water supply, electricity, roads, etc. at these places. As the townships grew up, recreation clubs, parks, playgrounds, hospitals, cinema halls and schools for the children were established.

To maintain close liaison between the employees specially the lower categories, and the management, a welfare officer has been posted at each of the big construction sites. Labour troubles and problems are tackled at the initial stage by these welfare officers, It has been always the policy of the Corporation to meet the reasonable demands of its employees, whether presented individually or collectively. In spite of this liberal attitude, its history has not been entirely without labour troubles. There have been a few strikes, but they were very short-lived, and in each case settlement was arrived at by mutual negotiation.

The Corporation believes that efficient service depends on the contended condition of the workers and its policy has been based on that belief. It cannot, however, be said that the Corporation has been able to satisfy all its employees and keep them contented, for, that is a mental condition which is impossible for any organisation to create and maintain.



▲ At 200-tons per hour, aggregate for damming the Damodar River moves by S-A Conveyor from the secondary crusher (right) foreground) to a battery of S-A screens over storage bins.

◀ A conveyor belt under these storage bins reclaims aggregate and moves it to the concrete batching plant as needed. Underground S-A conveyor is 720-feet long and handles 300-tons per hour.

S-A Conveyors Help Dam India's "River of Sorrow"

Flowing through the heart of India's fuel-metal producing center, the tranquil Damodar River becomes a raging torrent in the monsoon season. Property damage, and human misery follow, making the Damodar truly a "River of Sorrow."

The Damodar Valley Corporation, with a series of huge dams, has brought the river under control and converted the rampaging waters to the more useful job of producing hydro-electric power and irrigation.

Aggregate for the Maithon Dam, number three in the project, was supplied to the concrete batching plant by an S-A conveying system which included belt conveyors, screens, feeders and bin gates. The Stephens-Adamson equipment was furnished through Eastern Equipment & Sales Ltd. of Calcutta, associates of Atkins, Kroll & Co. located in San Francisco.

With the completion of the Maithon Dam in late 1954, the entire conveyor system was dismantled and relocated at the Panchet Hill Damsite. Again at work, it is another example of an S-A system "engineered for the job."

Stephens-Adamson equipment and engineering can team up to solve your conveying problems. Write for a survey.

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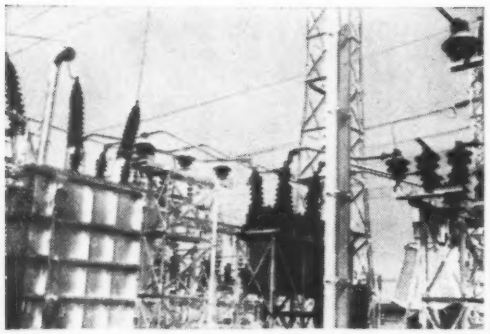

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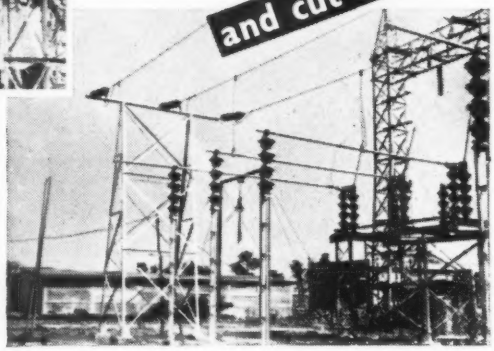

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Maithon Undergound Hydro-Electric Power Station

By

K. M. CHINNAPPA

Deputy Chief Electrical Engineer, D.V.C.

AUTHOR

The Maithon Project of the Damodar Valley Corporation, which is nearing completion, is the third of the 3 multi-purpose projects taken up in the first phase of development. Much has already been written on the general features of this Project and therefore it is now proposed to cover primarily the Power Station. However, for the sake of completeness basic hydrological data and general project features are also given.

This Project is on the Barakar river wich is the biggest tributary of the Damodar. The drainage area above the Maithon Dam is about 2,430 sq. miles. The hydrological studies are based primarily on the run-off records observed from 1933 to 1950; less reliable data for a considerable period prior to 1933 have been also taken into consideration. Additional gauging stations, since established by the Corporation, provide means for a reliable check on the stream flow records. It is believed that the estimates made of water flow are very realistic and the flood control storages available are sufficient to provide the desired absorption and subsequent regulated release of possible floods. The reservoir will have a total storage of 1.1 million acre ft. The dead storage, live storage for power and irrigation and the maximum controlled flood storage will be 1,68,000, 4,96,000 and 4,40,000 acre ft. respectively

The Project constitutes as shown in Fig. 1 a rock filled earth embankment on the original bed of the river, a concrete gravity dam on the diversion channel which forms the spillway section, a long earth dyke, portion of which will act as the breaching dyke and the power plant with appurtenances comprising the intake structure and tailrace. The figure also indicates how part of the diversion tunnel used during the construction is ultimately used as the tailrace.

The underground power station having an initial and ultimate installed capacity of 60,000 kW will operate at base load during the wet period when the inflow is appreciable and at peak load during the dry period, the daily and weekly release meeting the irrigation requirements. The large capacity at the Bokaro Thermal Power Station meets the entire balance energy requirement during the dry period thereby overcoming the inherent lower firm capacity of our hydro-stations.

The total cost of the Project is estimated at about Rs. 15 crores, out of which the Hydro-Electric installation will cost about Rs. 3.5 crores.

Power Station Layout

The flood control and irrigation aspects of this Project has been discussed in various publications earlier. The power aspect of the Project is now described.

The Power Station is located underground on the left bank of the river at a depth of 184 ft. below the road-way at the top of the dam. Access to the power house is through a horse-shoe shaped tunnel about 700 ft. long. The size of the tunnel and the gradient permit transportation of the heavy equipment into the power station. Entrance to this tunnel is fitted with rolling steel doors with a small door for personnel entrance. These doors will normally remain closed and air will be drawn into the power house through an air filter mounted separately. Fig. 2 and 3 indicate the general plans and typical section of the power station and equipment.

The power station was located underground for the following reasons:—

(a) A comparative estimate indicated that the underground power station in the left bank was cheaper than an overground power house in the right bank on the downstream side of the dam.

(b) The diversion tunnel required for the construction of the dam could later be used as tailrace by locating the power house in the left bank. Tailrace excavation costs were thereby reduced.

(c) The location permitted continuous construction of the power station by getting it out of the path of the monsoon floods. The power station construction parallels all other civil works and

will therefore be finished at the same time as the dam.

(d) The location gave the economical advantage of producing power immediately upon filling the reservoir.

(e) Foundation difficulties were overcome as the overburden in the Barakar river varied from 30 to 80 ft. calling for expensive power house foundations for the overground location.

(f) The excavated rock from the tunnel and power house provided rip rap for the protection of the dam slopes,as well as aggregate for concrete, if required.

The power station accommodates 3 units each of 25 MVA capacity. The layout of the turbo generator is horizontal resulting in the following advantages !

(i) The power station chamber will be only slightly over one half as high and of about the same width as required for vertical units, thereby greatly reducing excavation.

(ii) The elbows in the penstock ahead of the turbines, required in vertical units are eliminated and the penstocks enter the scroll cases tangentially.

(iii) The setting permits the use of a straight conical draft tube of simpler construction than an elbow type.

(iv) The absence of penstock elbows and adoption of the horizontal type draft tubes will conduce towards higher efficiency and smoother operation. The long length of the draft tube is in the direction of, and in lieu of an equivalent length of the tail tunnel.

(v) The time of construction and installation is materially shortened. Instead of some 16 or more pours of concrete from foundation level to generator floor, the generator can be founded nearly on bed rock after only one or two pours of concrete. Turbines and generators can be installed simultaneously.

(vi) The turbine and generator parts can be removed independently for purposes of maintenance.

The turbines are placed in niches, each of which measures 43 ft. long × 17.7 ft. wide × 47 ft. high. The generators are placed in the machine hall measuring 205 ft. long × 45 ft. wide × 65 ft. high. The roof is arch shaped with proper reinforcement and lining wherever necesssary. A drip-proof false roof is also provided. The access to each turbine is through a vault from the machine hall. The main power transformers are also located underground in vaults located alongside the access tunnel. The L.T. AC and DC equipment are located on the North-Eastern end of the power house.

There is no separate local control room within the power house. The necessary control for the local operation of the machines are brought out to panels mounted around the actuator cabinet for each machine. All controls are centralised on these panels. The actuator cabinets are a mounted on the downstream wall of the machine hall and on the left hand side of each turbine vault. The units are supervised from an overground control station.

The basement houses the battery room, M/G. sets, auxiliary transformers with associated switchgear and sewage tanks with ejector. Cable and pipe galleries are provided along the upstream and downstream walls of the power house basement. The 11 kV equipment are located in the cable gallery and will house the generator current transformers for voltage regulation and protection, the grounding transformer, generator disconnecting switch, surge protection equipment and the AVR potential transformers. The generator file protection CO_2 battery will also be located in the cable gallery.

The station service air compressor equipment are located in the basement to the south of the auxiliary transformers. The pwer station seepage and transformer cooling water will be routed to a sump located midway between units No. 2. and 3. The contents of the sump will be discharged to the tailrace by means of 4 vertical motor-driven pumps.

The generator bearing lubricating pump equipment and sump, governor compressor and the governor oil sump tanks are all located on intermediate platforms.

For handling equipment within the power station, a 115-ton travelling crane, having two trolleys each equipped with a 57.5 ton capacity hoist, is provided. The crane is also equipped with a monorail hoist of 10 ton capacity. To facilitate erection of turbine parts in the niches, three monorail hoists and a dismantling truck running on rails have been provided. An equipment hatch in the erection bay will permit lowering of the equipment to the basement for installation.

An emergency shaft 12 ft. in diameter and 184 ft. deep with a spiral staircase provides exit to the roadway on the top of the dam.

Conveniences like a small office, pantry and wash rooms are also provided underground.

Water Passage

The horizontal distance between the intake mouth and the turbine centreline is 153′-5″ The location of the intake structure has been so chosen as to place the power station in sound rock with ample rock cover above the roof. The intake structure located inside the reservoir has provision for separate intakes for the 3 units. The conduit at the intake service gate opening is 14′-0″ wide × 23′-9″ high and is closed by a single leaf, vertical lift type service gate operated by individual electrical hoist. To permit repairs after probable operational failure of the service gate or hoist, an emergency gate of the single-leaf, vertical lift,type measuring 14′-0″ wide × 27′-4″ high, has been provided, upstream of the service gate, common to the three turbines. The emergency gate is handled by

AUSTRALIA is equipping ITS FIRST NETWORK AT 330 kV with "SHELL-TYPE" TRANSFORMERS

Among the world irrigation projects under construction, one of the largest is certainly that being actively pursued by the Australian Commonwealth.

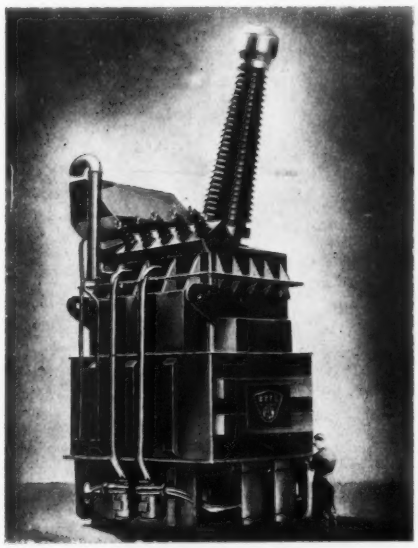
By utilising the hydraulic energy progressively liberated from the Snowy Mountains reserves, it is hoped that within a few years they will be able to dispose of 2 to 3 million kW.

From underground electricity power stations, this energy will be carried over very long distances by very high voltage three-phase line supplied by transformers at 330 kV.

As the result of a competition in which all the leading world known constructors were engaged, "ACEC SHELL-TYPE" transformers are the ones chosen for equipping the first power station. The order calls for 7 single-phase units of 56,000 kVA, 15/330 kV; these will constitute two three-phase groups of 168,000 kVA and 1 reserve unit.

This is the first time in Europe that such a large export order for very high voltage transformers has been passed to one firm.

This success is all the more noteworthy since these transformers have to comply with specifications based on the most exacting Australian and international prescriptions. Connected to a very long line, and exposed to violent thunderstorms, they will have to resist powerful lightning strokes. For this reason, they must undergo trials with artificial lightning "chopped waves" which have an amplitude of 1.5 million volts; this is one of the most severe standards ever accepted up till now.



One of the type 330 kV ACEC Transformers

It is certain that independent of the cost of the material, of inherent losses and valorisation of the dimensions, and bearing in mind the special operating conditions, the guarantee of absolute operating security has been the determining factor in the choice of the Constructor. The ACEC, upheld by their long experience were able to offer this guarantee.

As a matter of fact ACEC SHELL-TYPE transformers installed up to the present and totalling over 6 million kVA are in operation without causing the slightest trouble, some of them having been in service over 6 years under voltages of from 150 to 230 kV in all parts of the world and in varying climates.

This operating security is essentially due to the rational design of their construction.

In this design, the magnetic circuit in orientated crystal steel laminations, thus of very low losses, almost entirely encloses the windings of the high and low voltage electric circuits; it forms with them and the tank made of welded steel sheets, an extremely compact block of reduced dimensions and in particular has a high mechanical resistance to transport shocks and dynamic stresses developed when line short-circuits occur.

In this connection we may mention the case of a transformer of 30 MVA which during port loading operations fell from a height of 16 feet and which, on its return to the factory, satisfactorily underwent all the usual tests.

The insulated rectangular pancake windings, placed side by side and erected vertically, confer on SHELL-TYPE transformers most remarkable electrical qualities; in particular we would mention their exceptional high resistance to full wave and chopped wave shock tests. Some tests recently conducted by the 'Electricite de France' at its testing station at Fontenay on an ACEC SHELL-TYPE transformer picked at random, have shown that a unit in the 230 kV category constructed to resist 1050 kV only broke after 1550 kV, after having resisted 153 full wave and chopped wave shocks at voltages ranging from 1000 to 1550 kV.

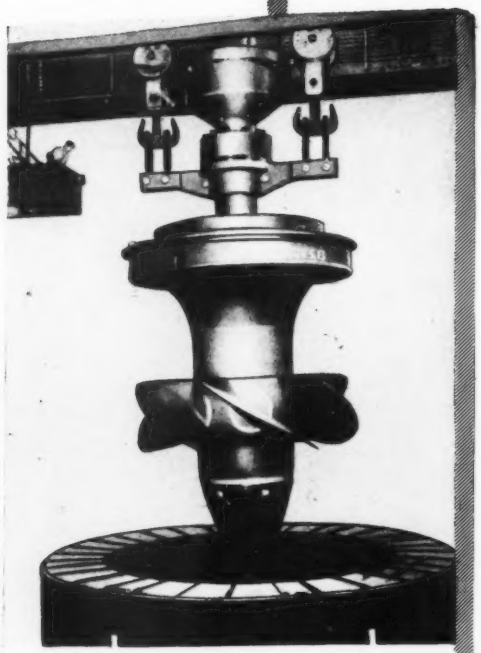
During these same tests on the powerful French Network at 220 kV, four sudden switching-on movements on open short-circuit did not cause any internal deterioration. Not one of the "Core" type transformers subjected to the same tests would have resisted in a satisfactory manner.

Finally, let us mention that their degree of security is such that in the U.S.A. large factories are currently using Westinghouse SHELL-TYPE three-phase units of 155,000 and 195,000 kVA without any reserve unit.

This is why the Australian Commonwealth has shown its confidence in SHELL-TYPE transformers constructed under Westinghouse licence by ACEC — Ateliers de Constructions Electriques de Charleroi, the powerful Belgian firm with a capital of 1 milliard Belgian francs.

HYDRAULIC TURBINE & GENERATOR
INDOOR & OUTDOOR SWITCHGEAR

UMBRELLA TYPE ALTERNATOR



ROTOR OF KAPLAN TURBINE

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means of a lifting beam attached to the intake gantry crane operating along a runway traversing the length of the intake deck. The gantry also serves for installing and dismantling the service gates and hoists. The service gate hoists are so designed that in case of emergency e.g. overspeed, excessive bearing temperature etc., the gate can automatically close in a very short time.

The rectangular section at the intake mouth is gradually transformed into a circular section of 14′-0″ diameter in a concrete transition length of 60′-0″. From this point the penstock is steel lined, the horizontal portion being 14′-0″ in diameter and 55′-0″ length, the reducing elbow from 14′-0″ to 13′-0″ in diameter being 55′-0″ in length, and the vertical limb being 13′-0″ in diameter and 20′-0″ in length. The lower end of the penstock is connected to the turbine spiral casing through a reducing taper 13′-0″/ 11′-6″ in diameter.

The dimensions of the water passage have been decided from economic considerations, commensurate with satisfactory speed and pressure regulation of the turbine on changes of load.

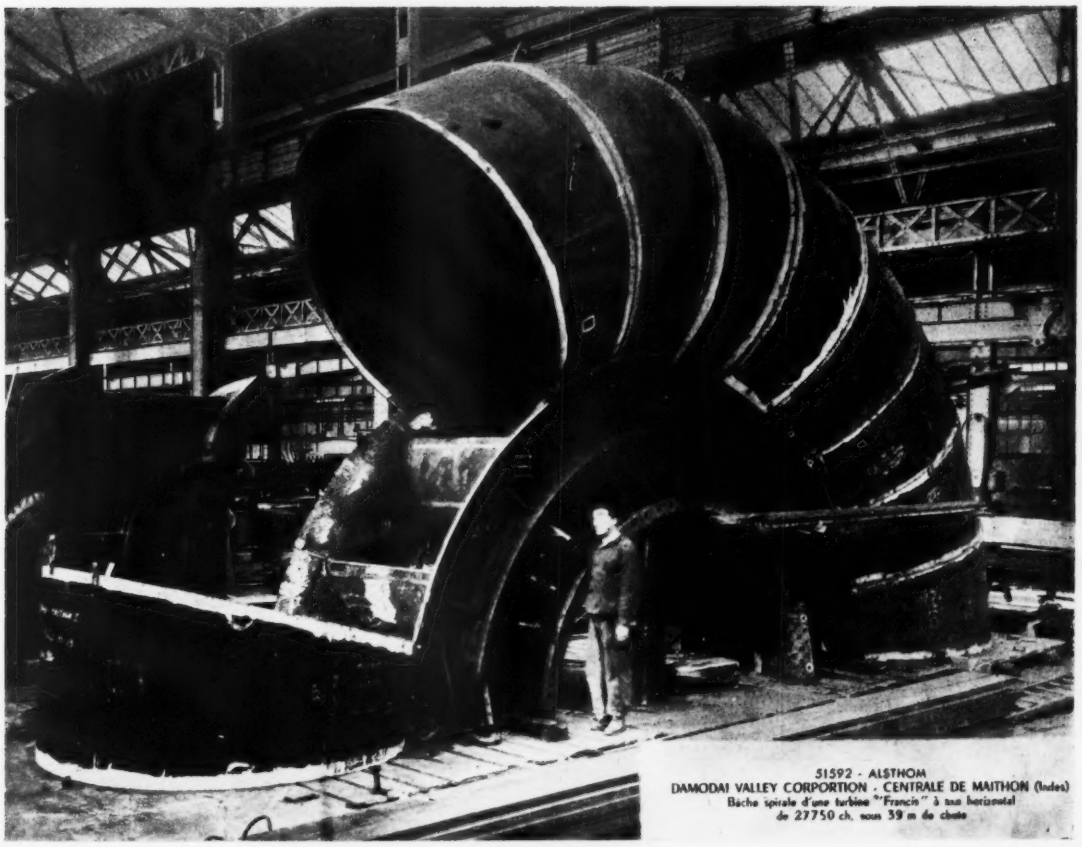
Surge Chamber

A surge chamber is located downstream of the power station and directly above the draft tube outlets. The chamber is common to all three units. The surge chamber is so dimensioned that it can suitably dissipate a surge which might occur from sudden rejection of full load from three units simultaneously with a tail water elevation corresponding to the normal flood discharge of 70,00 cft. The surge chamber also serves as the operating space for the draft tube gates. Suitable access to the surge chamber is also provided. A short separate tail tunnel is provided for each unit downstream of the surge chamber. These tunnels merge into a long common tunnel which utimately joins the diversion tunnel.

Main Equipment

Turbines

The hydraulic turbines of the horizontal Francis type are designed to operate under a net head varying from 79 ft. to 127 ft. and to deliver a guaranteed output of 27,750 B.H.P. at a normal speed of 176.5 r.p.m. under the design net head of 113 ft. The spiral casing and the draft tubes are of riveted and welded construction. The machine centre-line is about 18 ft. below the minimum tail water level and this is more than normally required to protect the runner and discharge ring of a turbine for a rated output of 27,750 B.H.P. under 113 ft. net head against pitting due to cavitation. Advantage has been taken of this deeper setting by



51592 - ALSTHOM
DAMODAI VALLEY CORPORTION - CENTRALE DE MAITHON (Indes)
Bache spirale d'une turbine "Francis" à axe horizontal de 27750 ch. sous 39 m de chute

increasing the normal speed of the turbine resulting in a turbine-generator set of smaller physical size, leading to further economy. The runner is of cast steel construction, with the rims cast integral with the vanes. Vent holes are provided on the runner hub to reduce the unbalanced hydraulic thrust.

The guide apparatus is of normal construction with renewable stationary wearing rings and facing plates made of carbon steel. The bearings for all the wicket gates are arranged for centralised forced grease lubrication. Each wicket gate is also provided with a suitable thrust bearing to resist thrust in both directions. The links are so designed as to break in case one or more wicket gates become jammed. Adequate means are provided to limit the angular movement of the wicket gate in case of breakage of the weakest element. This prevents interference of the loose gate with the closing operation of other gates in an emergency.

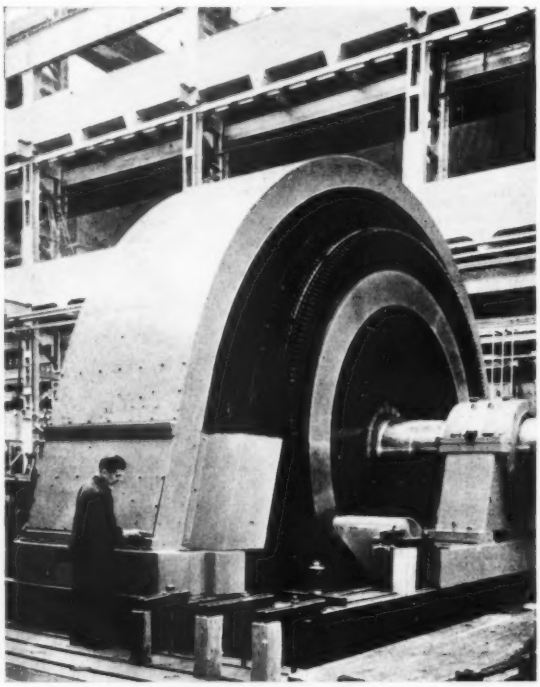
The thrust bearing is integral with the turbine guide bearing. The combined bearing is self-oil-lubricated from the oil reservoir mounted integral with the bearing. The oil reservoir is provided with cooling coils. The thrust bearing is capable of withstanding the maximum unbalanced hydraulic thrust in both directions, of magnitude 100 tons towards the draft tube and 30 tons towards the generator. The combined guide and thrust bearing is provided with a small motor driven oil pump to lubricate the upper side of the shaft during starting and stopping. Suitable temperature detecting elements, alarm and shutdown contacts are aslo provided. Each turbine is provided with two oil-pressure double-acting servomotors of a combined capacity of 167,000 ft. lbs. to operate the wicket gates under all conditions of head and load through their full stroke in a pre-determined time with the minimum governor oil pressure. The servomotors are securely fixed to the concrete foundations.

The turbine shaft is coupled with the runner at one end and to an extension shaft at the other end, which, in turn, connects to the generator shaft. The shafts are made of forged open-hearth steel properly heat treated. Great care has been taken during the manufacture of these shafts and complete physical and chemical tests on samples cut away from each forging have been conducted before acceptance.

Governors

The governing system for each turbine to control the speed comprises of actuator, servomotors, return-motion mechanism, oil pressure tank, two A.C. motor-driven oil pumps and one stand-by D.C. motor driven pump, manual and electrical control devices etc. All of these, excepting servomotors, are mounted inside a steel cabinet located in the machine hall. The pendulum of the actuator is driven by an asynchronous motor which is supplied by a permanent magnet-generator, gear-driven from the main generator shaft. The movements of the actuator caused by changes in the speed of the turbine consequent to changes in load are transmitted through valves to control the admission of pressure oil to the pistons of the servomotors to effect the correction desired. The servomotor pistons move the wicket gate regulating ring correspondingly until the return-motion mechanism prevents further movement.

All the controls for starting, regulating the speed of the turbine and stopping are mounted on the cabinet. The gate limiting and speed adjusting devices are electrical motor driven to enable remote control.



Alternator on the test bed

Generators

The generators are three-phase, 50 cycles per second, 176.5 r.p.m. 11 k.V rated at 25 MVA, 0.8 P.F. They are designed for a runaway speed of 350 r.p.m. The generators are equipped with direct connected main exciters and geared pilot exciters, rapidynes, permanent magnet generators, voltage regulators and excitation and supervisory cubicles. The voltage regulation system permits the following modes of operation:

(a) Automatic control with pilot exciter, rapidyne, main exciter and AVR in circuit.
(b) Manual control with pilot exciter, rapidyne, and main exciter in circuit.
(c) Manual control with pilot exciter and main exciter only in circuit.

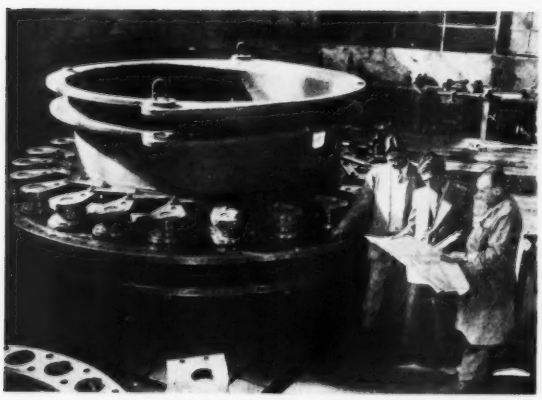
The rotor comprises two pole wheels pressed on to its shaft. The pole pieces are of the solid pole beam type with welded pole shoe laminations and are fastened to the rotor rim by means of screwed bolts.

Connected damper windings are also provided. The fly-wheel effect (WR^2) available is 8.18×10^{9} lb.ft.^{2}. A pneumatic brake acts on the rotor and is designed to bring the machine to rest from a speed of 88 r.p.m. in 5 minutes. The insulation of the stator, rotor and exciting machines is Class B throughout.

The generators are designed for unearthed operation. Earthing will be effected on the 11 kV side by means of a 5 limbed 3 phase 3 winding potential transformer. A relay connected to the open delta winding protects 90% of the machine winding by means of the fundamental displacement voltage. An additional third harmonic relay protects the lst 10% of the winding near the neutral.

Ventilation is of the closed circuit system. 8 Coolers are provided in the generator pit. The coolers are designed for a 35°C inlet water temperature, and for a working pressure of 25 to 75 psi. The test pressure will be 150 psi. With any 2 cooler elements out, the generator can carry at least 67% load. The temperature of the cooling air at the outlet will be 45°c. Flow alarms are provided in the cooling water line for the air coolers and for the bearings, and in the bearing-oil lines

The generators are furnished with the usual temperature detector elements embedded in the stator windings, in the bearings and in the cooling air. In addition to the usual brushes on the slip rings, an extra set of collector ring brushes, brush holders and terminals are provided for operating a rotor temperature detector.



Maithon Distributor assembly at Ets. Neyrpic's works

Guide bearings are located on either side of generator. Main exciter is also provided with a guide bearing on the upsteam end. Two oiler rings are provided on the shaft in each bearing. One AC and one DC stand-by oil pump rated at 4 kW and 415 volts 3 phase 50 cycles AC and 250 volts DC respectively are provided for the purposes of lubrication. Two 100% bearing oil surface coolers are provided to cool lubricating oil. The bearings are designed to operate at a temperature of 60°C. Two jacking pumps each rated at 1.5 kW, 250 volts DC are provided on each bearing to lift the rotor during starting and shut down. All bearings are insulated to prevent flow of shaft currents.

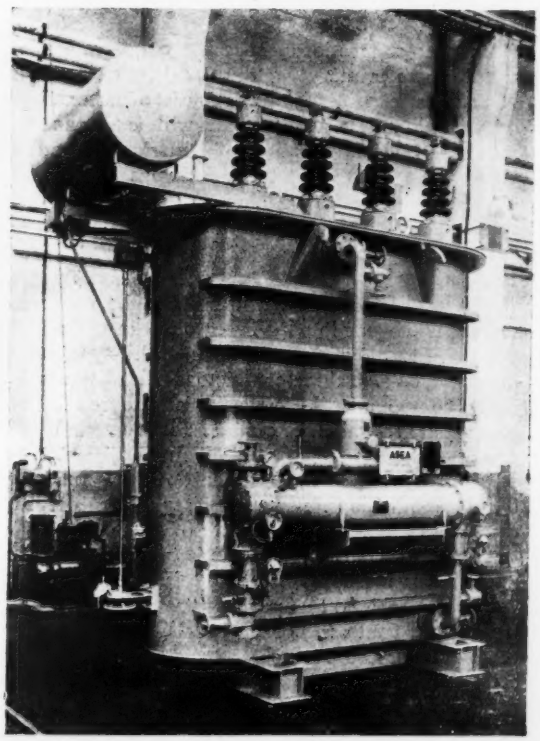
Transformers

The step-up transformers are of the OFW 3 phase type and has a rating of 25 MVA each. They will be connected solidly to the generators for unit operation. The no-load voltage ratio is 11000/33000 and the connection is delta star. Windings are fully insulated and not graded. These forced-oil water-cooled transformers are equipped with two 100% capacity coolers. The oil pump motors are rated at 2.2 HP 415 volts 3 phase 50 cycles AC. The coolers are designed for cooling water temperature of 35°C and a pressure of 6 psi. Cooling water is tapped from the turbine scroll case and thence reduced in pressure from the header pressure of 61/34 psi. to 6 psi. The water pressure at the cooler outlet is almost zero. The water drains under gravity into the station sump and thence to the tail race by the sump pumps. The quantity of water required per cooler is 80 g.p.m.

The transformers are provided with off-load ratio adjusters for rated KVA output and a voltage variation of $+7\frac{1}{2}\% + 5\%$ and $\mp 2\frac{1}{2}\%$.

Signalling and tripping contacts for failure of oil and water flow, maloperation of tap changer, excessive winding temperature, gas production, oil turbulence and other usual devices are provided.

One of the 3 Transformers ASEA Type TST-8000, 25,000 kva, 33,000/11,000 Volts, 50 Cycles, for the Damodar Valley Corpn. Maithon.



Each transformer is located in a separate vault adjacent to the access tunnel The transformers being of the outdoor type the vault has no drip proof roof. The vault openings are provided with rolling steel doors which will be kept normally open. Ventilation of the vault is aided by an exhaust fan provided at the top of the 11 kV bus duct which exhausts the air into the power house basement. Fire protection will be either by carbon dioxide or chlorobromomethane. In the event of a fire, the exhaust fan will shut down and the steel doors will close under pressure and/or fusible link tripping.

The transformers will be normally moved into the power station, as shipped, on a rubber tyred trailer, and assembled with the help of the power station crane and then rolled to their respective vaults on their own transport wheels.

Facilities for untanking the transformers will also be provided in the power station. For this purpose, the transformers will be lowered through the equipment hatch and then untanked by means of the power station crane. A floor trough or dwarf walls will be provided in the El. 310.5 floor to prevent migration of oil during untaking. This procedure has enabled the power house height to be kept low consistent with the requirements for moving only the generator rotor and stator halves.

Chilling sumps are also provided in the transformer vault basement to collect spilt oil. The oil will be discharged into the tail race by means of a pump.

Bus bar connections between the generators and transformers primary windings will be designed for 1500 amps. capacity, and will consist of either copper or aluminium flats. The bus bars will be screened and mounted on bus supports of American Standard, Class 15H (A-20) rated 15 kV. All bus bars are laid out in a single tier formation and are suspended from the roof in the cable gallery.

High Voltage Cables

The transformer HV winding will be connected to the switchgear located overground in the switchyard by means of two 0.4 sq. in. solid type, paper insulated, 35 KV, three-conductor shielded, non-migrating compound filled, flat-band armoured cables, connected in parallel. The cables will be carrried at the crown of the access tunnel and run up a gradient of 12% for about 630 ft. and then down a gradient of 8% for about 750 ft. As the cables will be subject to a maximum ambient temperature of 50°C and run on gradients referred to above the terminating potheads and trifurcating boxes will be oil filled and provided with a suitable oil reservoir. The potheads in the transformer vaults will be mounted horizontally while those outdoor at the switchyard will be mounted vertically. The combination of cables will have a current carrying capacity of about 450 amperes. A rating factor of 59% has been adopted for the site conditions.

The cables, with their joints and terminals will be designed to meet the same impulse level as that of the transformers viz. 250 kV with a 1/50 micro-second impulse.

Auxiliary Power Supply

Auxiliary power supply in the station is at 415 volts 3 phase 50 cycles AC and at 250 volts DC. All auxiliary AC power is derived from the grid and/or the generators. For this purpose a dry 3-winding, 11/3.3/0. 415 kV delta/star/star 600/200/400 MVA unit auxiliary transformer is connected in tee with each generator. A 11 kV remote motor operated disconnecting switch is interposed between the generator and unit auxiliary transformer tee-off connection. The opening or closing of this switch will permit the main power transformer to be operated as a step-down or step-up unit. During step-down operation auxiliary power will be derived from the grid. During step-up operation the auxiliary power will be derived from the generator.

The power requirements of the switchyard and dam auxiliaries are obtained from the 3.3 kV windings. The switchyard and dam auxiliaries are located at a distance of 550 and 900 yards respectively from the unit auxiliary transformers. Separate 200 KVA transformers step down the voltage from 3.3 kV to 415 volts for auxiliary power supply at the switchyard and dam respectively.

The main station service board is divided into two sections. One section is fed by 2 transformers and the other by a third transformer. The two sections are connected by means of a bus coupler.

The AC auxiliary power system is controlled from control panels located in the control station overground. This panel will control all the 3-transformer incoming 415 volts breakers, the bus coupler breaker, the 3.3 kV breakers, and also the switchyard and dam auxiliary board 415 volts incoming breakers. Paralleing of any of the transformers is avoided by the provision of cylindrical locks in the control switches of the associated breakers. The locks will permit the operator to use his judgement to avoid paralleling.

The DC system is 250 volts ungrounded. The battery will comprise a 120 cell 200 AH bank of lead acid type, control bus accumulators The battery will be float charged by a 10 kW M/G set at 258 volts. Two identical M/G sets are provided which are capable of operating in parallel for battery charging and/or supplying load. In view of the variable continuous load on the DC system the M/G sets will be equipped with an automatic voltage regulator of the rheostatic type. Alternatively it is proposed to use a diverter pole constant potential generator with a highly drooping characteristic beyond full load. Either of these will maintain a steady voltage from no-load to full load. The continuous load on the DC system will be about 3 kW; starting and shut down load will be 4.5 kW; and variable loads of the order of 4.5 kW.

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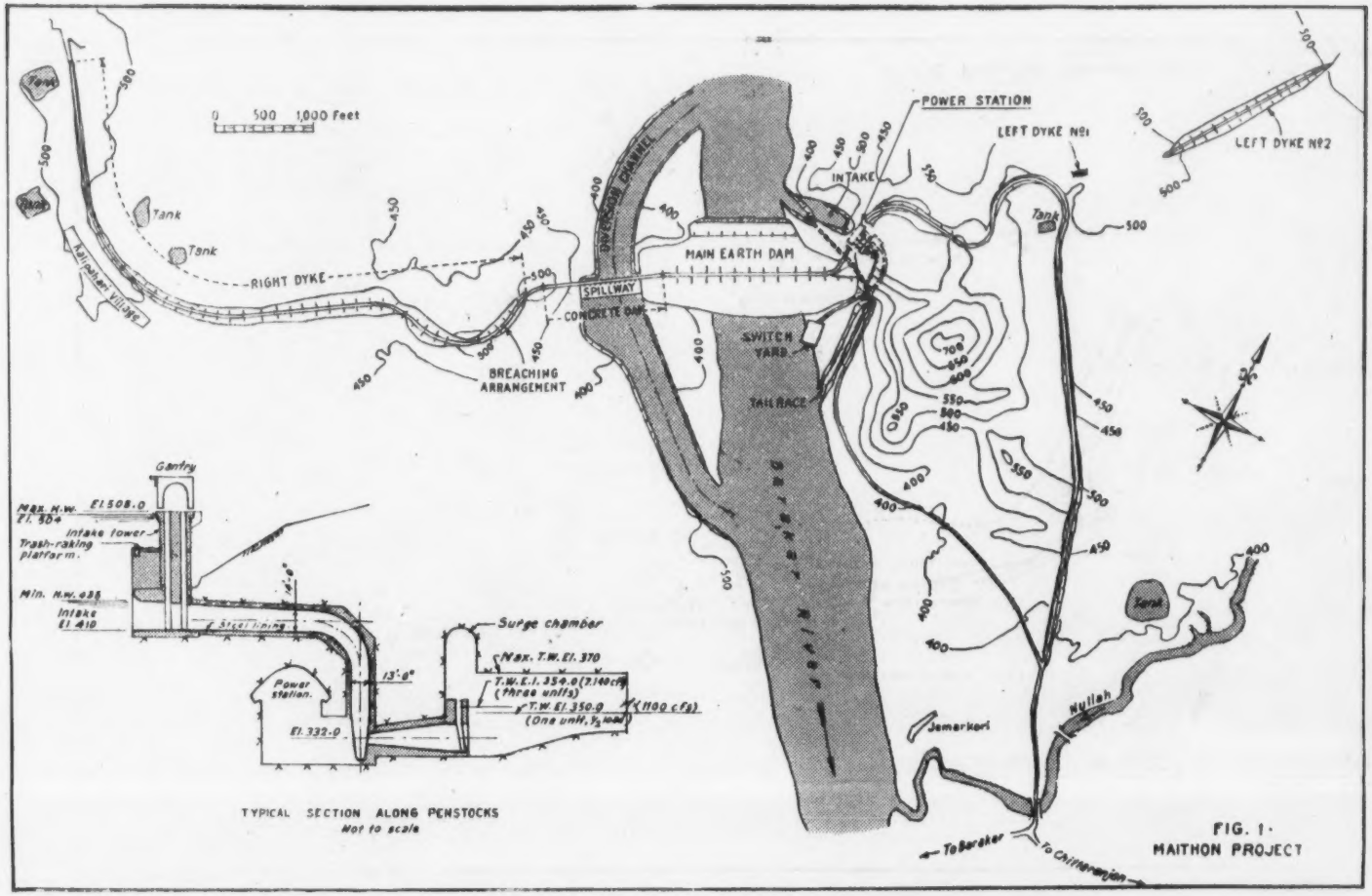


TYPICAL SECTION ALONG PENSTOCKS
Not to scale

FIG. 1.
MAITHON PROJECT

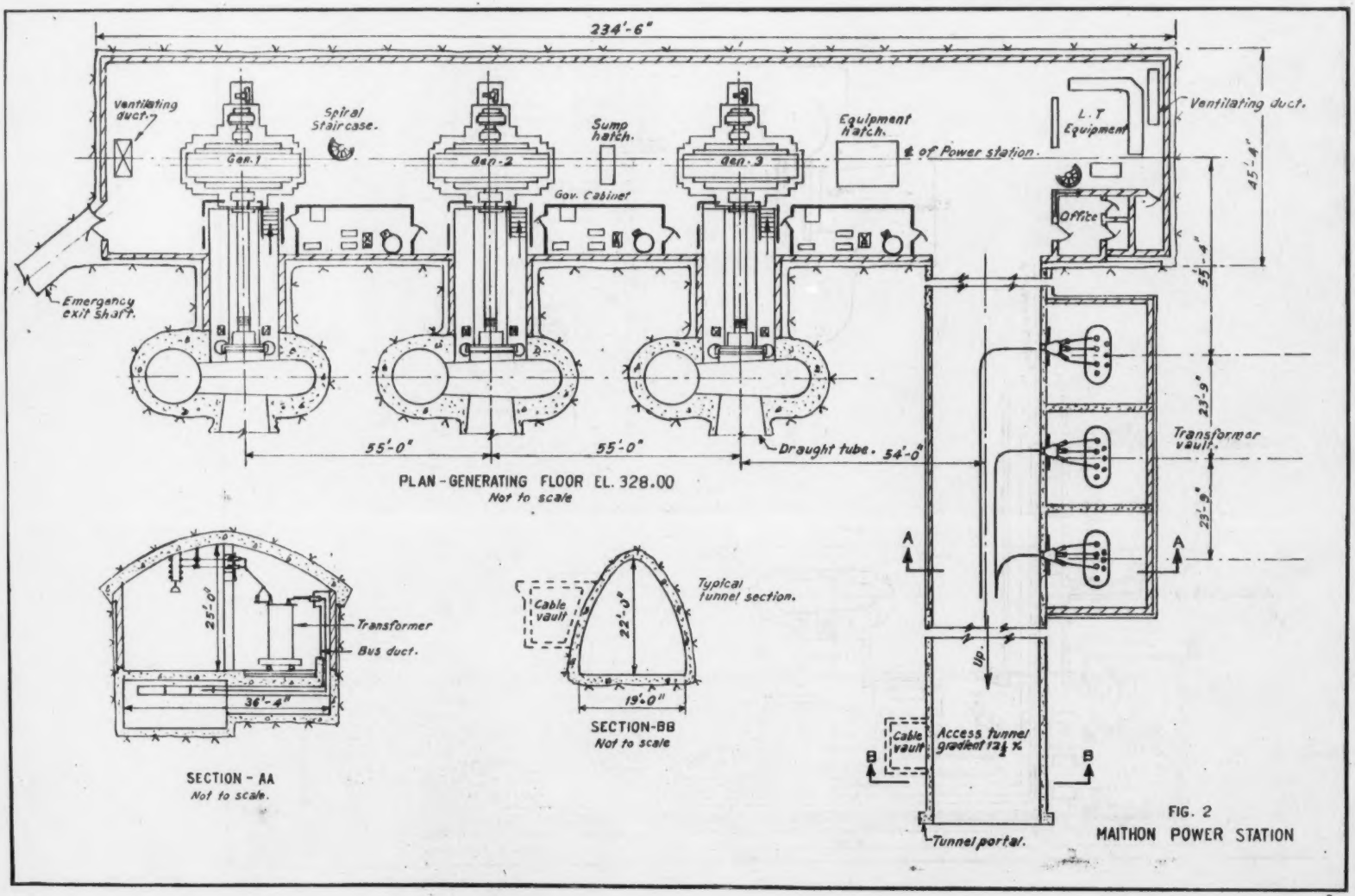


FIG. 2
MAITHON POWER STATION

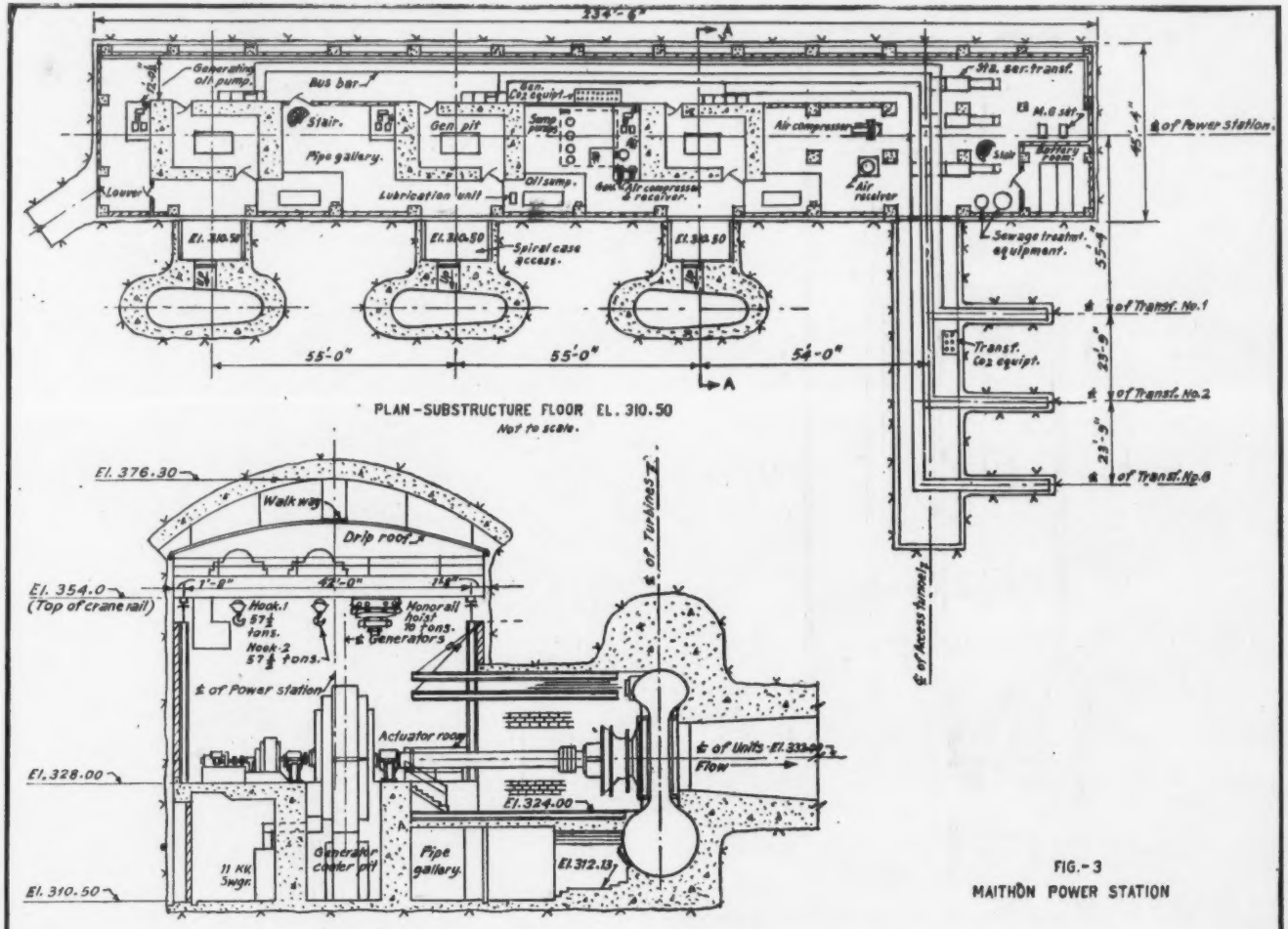


FIG.- 3
MAITHON POWER STATION

SECTION AA
Not to scale

FIG.-3
MAITHON POWER STATION

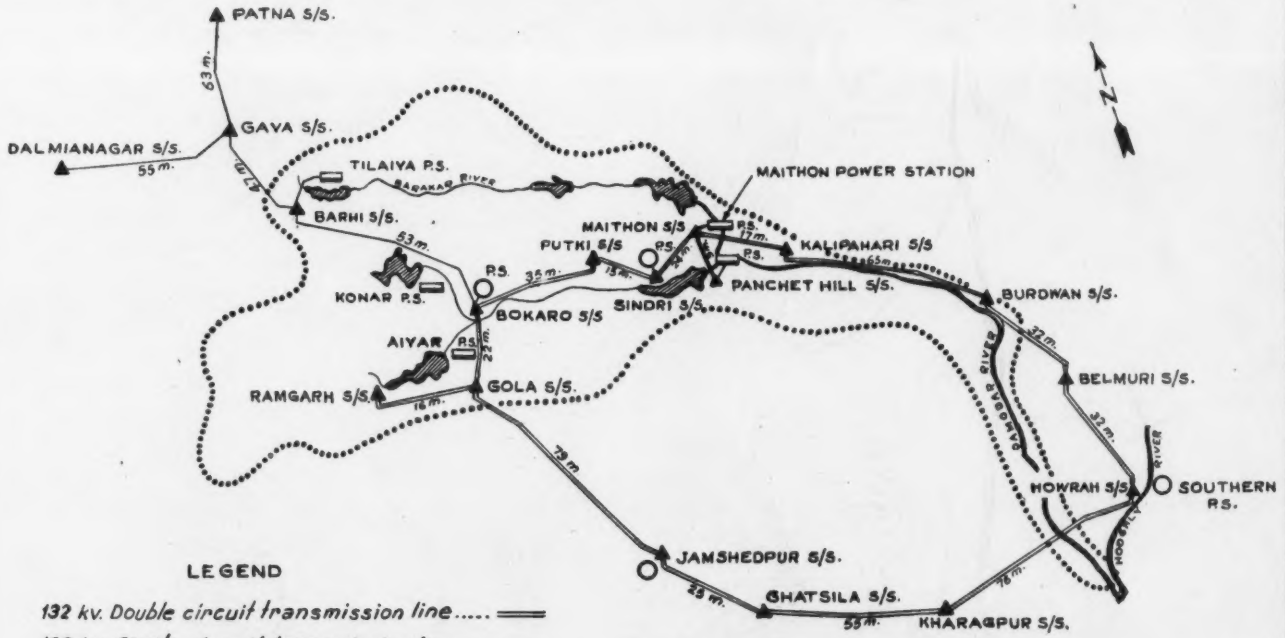
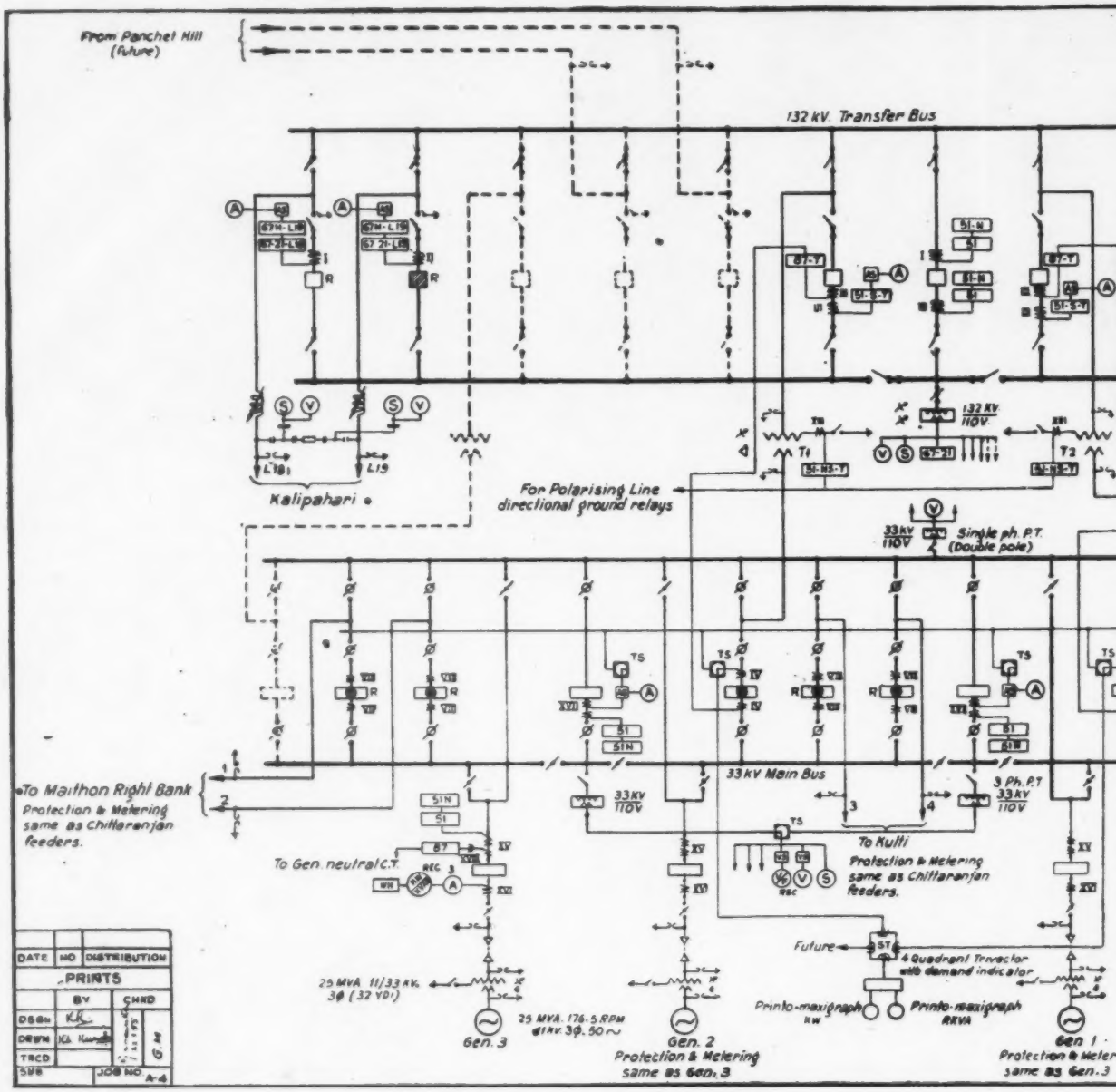


Fig. 4
D.V.C. POWER TRANSMISSION SYSTEM


From Panchet Hill (future)
132 kV. Transfer Bus
Kalipahari
For Polarising Line directional ground relays
132 KV 110V
33KV 110V
Single ph. P.T. (Double pole)
T1
T2
33 kV Main Bus
3 Ph. P.T 33KV 110V
To Maithon Right Bank
Protection & Metering same as Chittaranjan feeders.
To Gen. neutral C.T.
To Kulti
Protection & Metering same as Chittaranjan feeders.
Future
4 Quadrant Trivector with demand indicator
Printo-maxigraph KW
Printo-maxigraph KVA
25 MVA 11/33 kV. 3φ (32 YD1)
25 MVA. 176.5 RPM @ kV. 3φ. 50~
Gen. 3
Gen. 2
Protection & Metering same as Gen. 3
Gen. 1
Protection & Meter same as Gen. 3
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DISTRIBUTION
PRINTS
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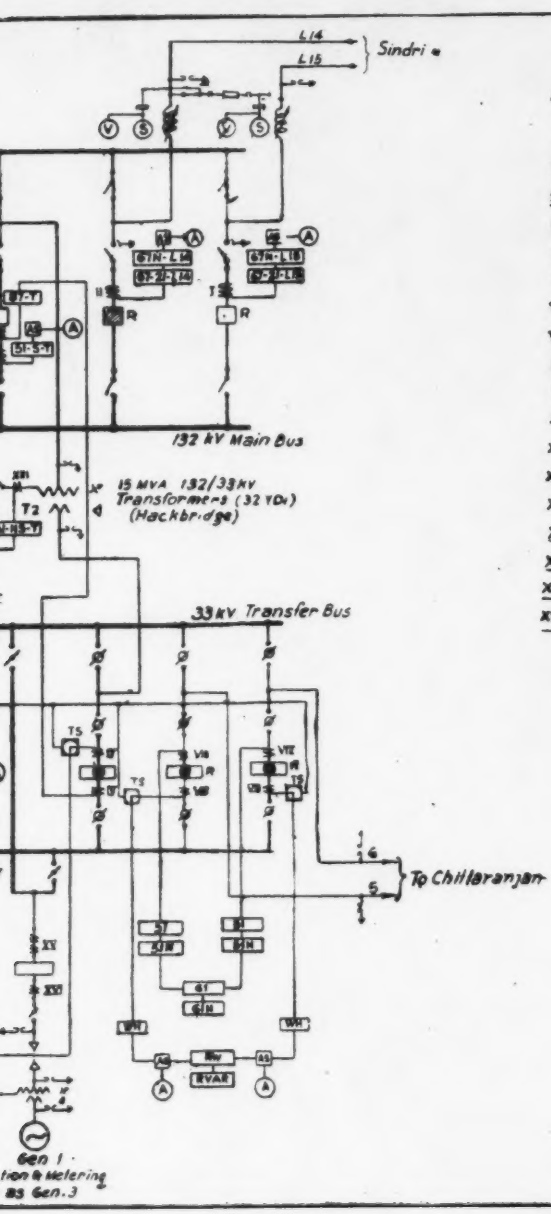
SVS
JOB NO
A-4



C T RATIOS

(Ratios which apply to this substation are underlined)

I	600-500-400-300-200/5
II	600-300-150/5
III	200/5
IV	400/5
V	800/5
VI	1200-600/5
VII	150/5
VIII	200-150/5
IX	200-100/5
X	600/5
XI	400-200/5
XII	400-300-200/5
XIII	600-200/5
XIV	250/5
XV	500/5/1 (5 Amp. core 25 VA, 1 Amp core 15 VA)
XVI	500/5
XVII	500-300-150/5/5 (One core 30 VA Class CN other core 25 VA for relay)
XVIII	1/1/3 (mounted in control board)

DEVICE LEGEND

DEVICE NO	FUNCTION
21	Distance relay with carrier
51	A.C. Overcurrent relay
61	Current balance relay
67	Directional relay
87	Differential current relay
N	Neutral (Earth fault relay)
S	Stand by (Back up)
L	Line
T	Transformer
	132 kV. O.C.B. (F.P.)
	132 kv. O.C.B. (Oerlikon)
	33 kV. O.C.B. (Asea) with separately mounted CTs.
	33 kV. O.C.B. (Reyrolle) with bushing type C.Ts.
	132 kV. isolator (Mitsu)
	33 kV. isolator (Asea)
	33 kV. isolator (G.E.C.)
	Link switch
kW	Recording wattmeter
kVAR	Recording varmeter
WH	Watthour meter
	Breaker with recloser
V	Voltmeter
A	Ammeter
S	Synchroscope
TS	Transfer switch
AS	Ammeter switch
VS	Voltmeter switch
REC	Recorder
	Summation transformer
	Lightning arrester
	Wave trap
	Capacitor, potential & carrier device
	Future equipment shown dotted

NOTE:

1. The feeders to Sindri and Kalipahari have been interchanged to line up with the physical location.
2. The control panel circuit sequences shown in I.G.E. drawing remain unaffected. After erection transformer numbers 1 and 2 should preferably be interchanged.
3. On I.G.E drawings the 33 kV feeders no. 1 & 2 are marked to Kumardhubi and Dishergarh.
4. For generator circuit, synchronising etc. see drg. no. G-N 262

3	4.56	Modified and redrawn		G N		
2	3.45	Redrawn				
1	3.52	Supersedes drg. S-193				
REV. NO.	DATE	NATURE OF REVISION	BY	CHKD	APPD	

DAMODAR VALLEY CORPORATION
ELECTRICAL DEPARTMENT

MAITHON GRID SUBSTATION 132 KV.

SINGLE LINE RELAY AND METERING DIAGRAM

D.V.C.E.E. — C.E.E.E.

PROJECT ENGINEER

DATE 19.1.55

DRG. NO S-C 11

The battery capacity is adequate to supply an emergency station lighting load of 12.5 kW for 3 hours, or starting power for all essential auxiliaries after an emergency shut down. In addition to the above it can supply its normal continuous load for a reasonable time. The switching arrangement will permit the battery to be isolated from the bus and independently charged at a quick rate at a higher voltage than the loads can stand. The M/G set rating is such as to permit recharging the battery in about 6 hours after an emergency shut down. During such periods the second M/G set will be connected to the station bus for supplying starting and other loads.

Control System

The control system has been so designed that each generating unit can be started up and brought to normal speed,

either

(a) through master push-buttons located in the underground actuator cabinet and in the overground control panel on the principle of semi-automatic sequential parallel system. The head gate will open, all the auxiliaries will start functioning, the governor solenoid will be energised to open the wicket gates and finally when the unit has reached normal speed, the transfer relay will energise signalling to the overground control station that the unit is ready for synchronizing.

Or,

(b) through individual push buttons located on the actuator cabinet to start each of the auxiliaries separately and to carry out the various stages of starting-up operation step by step with necessary interlocking to prevent maloperation.

In either case the annunciation and alarm system will be put into service at such stages when it is expeced that all auxiliaries have started functioning. In case of semi-automatic control, however, if the unit does not reach normal speed within a pre-determined time, an excess time relay will operate to completely bring the unit to standstill.

Normal shut-down of the unit will be effected by 'stop' push buttons located in the underground actuator cabinet and in the overground control panel for automatic operation and also by individual push-buttons at the actuator cabinet for step by step operation.

Protection & Metering

The generator/transformer protective gear comprise the following:—

Generator

Stator Earth fault 100% winding protection;
Differential protection across generator;
Rotor earth fault protection;
Overvoltage and operspeed protection.

Main Power Transformer

Restricted earth fault protection of 33 kV winding
Buchholz protection.

Generator/Transformer/33 kV Cables

Differential protection;
Back-up over current/earth fault protection.

Unit auxiliary transformer

Overcurrent protection (11 kV side);
Generator/transformer differential.

In view of the long distance (550 yards) between the generators and the switchgear one ampere secondary CTs will be used to keep the lead burden low. Relays located within the power house will be operated off standard 5 ampere secondary CTs.

An elaborate tripping and signalling arrangement has been adopted for each turbine-generator-transformer unit.

Emergency shutdown of the unit will be effected automatically on the opeation of any of the protective relays associated with turbine, generator and transformer provided for this purpose or manually by means of emergency shutdown push buttons located on the actuator cabinet and in the control station. For electrical faults which are likely to cause damage, the unit will undergo shutdown to standstill in which the 33 kV oil circuit breaker, generator field breaker and governor solenoid will be instantaneously tripped. For mechanical faults e.g. overspeed, excessive bearing temperature etc., the unit will also undergo shutdown to standstill in which the governor solenoid is instantaneously tripped, but the 33 kV oil circuit breaker is tripped after the wickets gates have closed to speed no-load position and the generator field breaker is tripped after the unit has come to rest. The differentiation in emergency shutdown is considered desirable, as in the second case, there will not be instantaneous rejection of full load and the generator field will help in the retardation of the rotating mass. For other non-damaging electrical faults, the generator and transformer unit is isolated instantaneously from the grid but the turbine continues to run at the normal speed.

The generator instrumentation and metering is conventional. The instruments are mounted on control panels located overground in the control station. A temperature indicator mounted on the generator located in the power house will indicate the winding temperatures at various points through a suitable selector switch.

Miscellaneous Equipment

Fire Protection

Fire protection in the power station is basically by CO_2 system. A separate CO_2 battery is provided each for the protection of the generators and transformers. The battery is however common for the three

generators and 3 transformers respectively, as it is assumed that not more than one machine will be involved in a fire at any one time. Wall mounted 15 lbs. CO_2 units will be located at strategic points in the power station. 50 lbs. $C0_2$ wheeled units will also be located, one each in the machine hall floor and the basement.

Other precautions taken are the provision of dry type auxiliary trasformers, air circuit breakers instead of oil circuit breakers, and use of instrument and protective transformer of the air insulated and non-inflammable fluid filled types.

Unwatering System

The unwatering system comprises 4 vertical submersible pumps with non-clog impellers driven by 40 HP AC squirrel cage motors. Each motor is provided with an air break direct-on-line starter of the combination type. The pump operation is automatic through floatless electrodes and the sequence of starting of the four pumps in succesion is controlled by a 4-pump automatic sequence alternator in order that the wear and tear of each pump could be equalised.

A float operated high water alarm contact is provided to signal high water level in the sump.

Raw Water System

The raw water system comprises a main header which is fed from the three spiral casings. Suitable tee-off connections are taken from the header through valves to meet the cooling water requirements for each turbine-generator unit. The main header also serves the main transformers and other station service auxiliaries. The outlet water from all equipment, excepting transformers, flows directly into the tailrace.

Ventilation

An important problem in a sound design of an underground station is adequate ventilation. In Maithon the ventilation system comprises three exhaust fans of the axial flow type, each rated for 40,000 cfm of air under a static water head of 2 inch. The fans are located inside a structure on the top of the emergency exit shaft. The air is drawn in through the main access tunnel and to counter against occasional dust storm the air is fed through mechanical self-cleaning filter. Control louvres of the fixed and and adjustable type are provided at key points inside the power house in order to maintain uniform distribution and temperature of the incoming air throughout the power house.

Switchyard and Control Station

The control as indicated earlier is from a control station, located near the switchyard, which is overground at the downstream side of the earth dam indicated in Fig. 1. From this control station it is possible to start up, synchronise and load the generating units. The auxiliary AC power system, as indicated earlier, is also controlled from this overground location. In addition to the above-mentioned controls, the station will have other panels controlling the spillway gates, the 132 kV line and transformer breakers, and the 33 kV feeder breakers of the Maithon 132 kV grid substation which forms part of the DVC Transmission system. This substation will have an ultimate transformer capacity of 45 MVA. The power station with the overground switchyard in relation to the DVC Electrical System is shown in Fig. 4.

Erection

In view of the underground location of the power station with an access tunnel, the dimensions of which are limited by economic considerations, the turbine-generator equipment will be brought into the power station in suitable sections for assembling at site. Of particular interest will be the erection of turbine spiral casing, draft tube liners, runner and generator rotors.

To erect the spiral casing and draft tube which involve welding of successive sections, special erection tools like lattice masts, monorail hoists in the turbine niche will be utilised. Lattice masts will keep the stay ring in position when the spiral casing sections will be welded to each other, and finally rivetted to the stay ring. The assembled spiral casing will then be pressure-tested to detect distortion or leaks. The turbine runner and shaft will be individually brought into the vault and assembled together. This assembly requires the use of a dismantling truck and special supports. Provisons will be made to adjust the height of the support so that the runner and shaft assembly may be moved into position, maintaining suitable clearences from the stationary parts.

The generator rotor spider will come in two sections and each section will be shrunk to the generator shaft in the power house erection bay. The poles will be fitted to the spider after the spider with the shaft is placed on its bearings in situ.

Other equipment erection deserves no special mention.

Conclusion

It is expected that this station will go into operation by 1956-57 when the system will be augmented by a capacity of 75 MVA and energy by 164 million KWH. The completion of this station will be followed by the 40 MW unit at Panchet Hill Hydro Station, having an ultimate capacity of 80 MW. It is likely that the fourth 50 MW unit will be installed at Bokaro and the 40 MW capacity Konar Hydro Station will also be taken up for construction forthwith. This will raise the system installed capacity to 367 MW, firm capacity to 284 MW to meet an anticipated system load of 284 MW at 60% load factor in the year 1959-60. This appears to be only the beginning. Also if the Coke Oven Project of the West Bengal Government, to be located at Durgapur, materialises, it will include a 30 MW capacity thermal plant which will be interconnected to the DVC system. The DVC system, in addition, will be connected to the neighbouring large

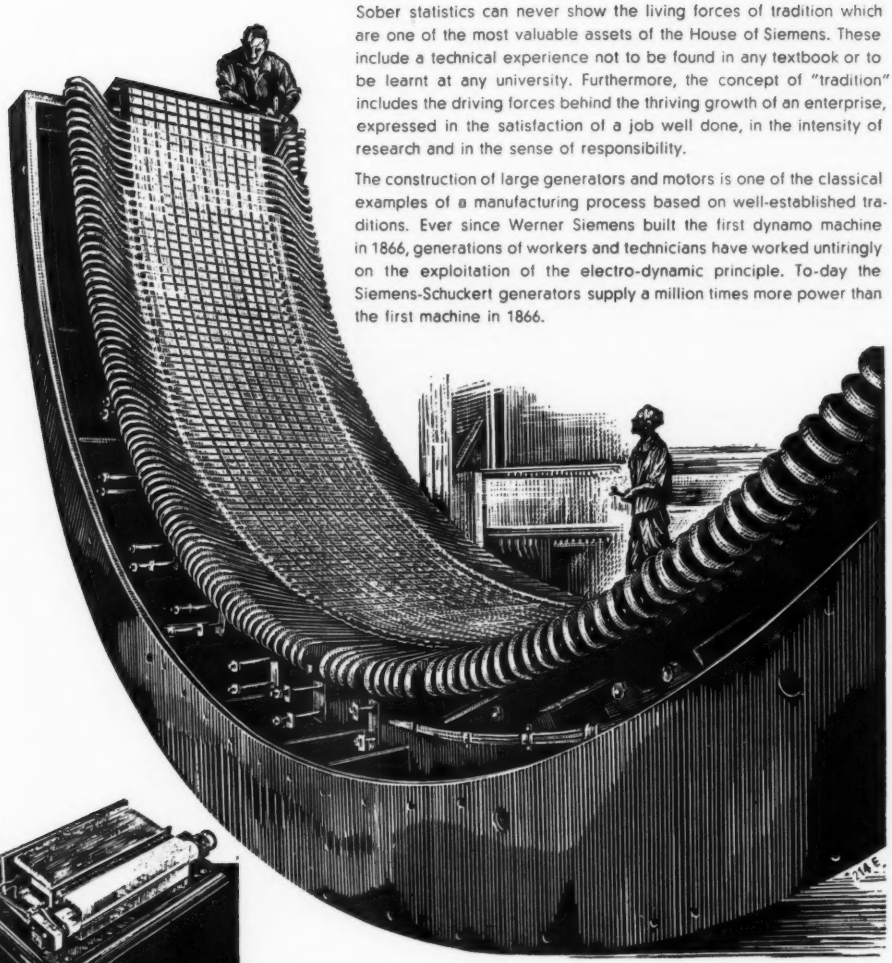
[*Continued on page* 53

SIEMENS

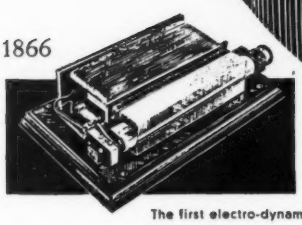
Tradition - a living force

Sober statistics can never show the living forces of tradition which are one of the most valuable assets of the House of Siemens. These include a technical experience not to be found in any textbook or to be learnt at any university. Furthermore, the concept of "tradition" includes the driving forces behind the thriving growth of an enterprise, expressed in the satisfaction of a job well done, in the intensity of research and in the sense of responsibility.

The construction of large generators and motors is one of the classical examples of a manufacturing process based on well-established traditions. Ever since Werner Siemens built the first dynamo machine in 1866, generations of workers and technicians have worked untiringly on the exploitation of the electro-dynamic principle. To-day the Siemens-Schuckert generators supply a million times more power than the first machine in 1866.



1866



The first electro-dynamo machine built in 1866 by Werner Siemens

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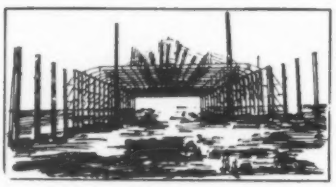

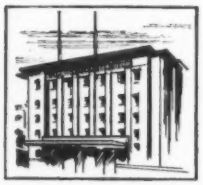

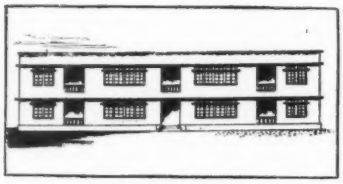

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My Experiences in the Execution of Barrage & Irrigation Project, Damodar Valley Corporation

D. MOOKERJEA

This is a bold contribution analysing the causes of delay in the execution of the Barrage and Irrigation part of the Damodar Valley Project, coming as it does from one who is incharge of its execution today. We welcome this critical approach of one's own job, surrounded as we are generally by a complacent and defensive mentality. Mr. Mookerjea has surveyed briefly the history of this project and pointed out at every stage where due to lack of decision or proper advance planning work was held up. But he has also drawn positive lessons from this analysis for future guidance. He has also pointed out the practical difficulties that were met in in the matter of construction work, which has reference to the controversy between departmental construction or construction by contract. We hope readers will be greatly benefitted from this thought-provoking and frank discussion by the author.

AUTHOR

The history of Damodar Flood dates back from the early part of the last century and measures to control this river which has always been considered as the 'river of sorrow' have been given serious consideration by the Governments both in the Centre as well as in the States. The rough and ready method of preventing the flood damages was adopted originally by erecting embankments along both the banks of the river from the point where the river used to spill over the banks and cause damage to the countryside. The river Damodar carries a heavy amount of silt load from its upper catchment and deposits the same in the lower reach of the river. This process has been accentuated by gradual deforestation of the catchment area and thereby allowing the land in the steep hill side slopes to be eroded by the rain-fall. With the gradual rise of the river bed level, the high flood level in the river also simultaneously started rising thereby exerting undue pressure on the embankments and making their maintenance more and more difficult. It is at this stage that the that the breaches of embankments were very frequent. With the gradual introduction of the railways and highways on the left bank of the river it was considered necessary to protect and maintain the left embankment even at the sacrifice of the right bank area. The right bank embankment was, therefore, gradually abandoned and the river was allowed to break through the abandoned embankment and spill on the right bank so that the vested interests on the left bank may not be seriously endangered.

Background of the present Project

Within a few decades following this practice it was found that the area lying beyond the left embankment and extending upto the Hooghly river was rendered impoverished on account of the lack of silt used to be carried by the spill of the river Damodar. The public health of the country also deteriorated. This was due mainly to the embankment shutting out the spill of the Damodar River. It was felt that could the river be re-introduced into this area, an useful purpose could possibly be served. With this end in view a survey was taken up in 1933.

The policy of maintaining the water-tightness of the left embankment of the Damodar has not only failed in easing the flood situation but also brought in its train disastrous effects on the country side. With the prevention of silt carried by the flood water from being deposited on the fields the land gradually recorded a poorer yield per acre. Moreover, the existing channels of Kana Nadi, Kana Damodar, Behula, Gangur etc. which used to function as arterial spill channels have been gradually rendered moribund on account of reduced head-water supply. The situation has been further aggravated by reckless construction of cross-dams erected across these channels with a view to irrigating the adjoining fields by means of whatever small discharge is found at their disposal. Apart from the water-logging of the vast areas following this mal-practice, the other and a far more serious consequence is the appearance of Malaria in an epi-epidemic form.

It was not until the beginning of the twentieth century, as a result of keen observations and actual experiments, that the principle of combination flushing and drainage was recognised as the only means of combating malaria, even though as far back as the late "seventies", the remarkable and immediate amelioration in health that followed the introduction of the Damodar water into the Kana Nadi through the Eden Canal System constructed instance of Sir Ashley Eden was noticed. In short, the remedial measures to combat the evils described above will consist of:—

D. Mookerjea, S.S.E., M.I.E. (Ind.), *is Project Manager, Barrage & Irrigation, Damodar Valley Corporation.*

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(*a*) The prevention of flood in the lower valley.
(*b*) The flushing and irrigation of the lower valley.
(*c*) The removal of surface drainage congestion.

The urgency for implementation of these measures was greatly realised when in July, 1943 the left embankment of the Damodar River breached and the flood water of the Damodar washed away the Eastern Rly. Embankment, G. T. Road and completely isolated the Far Eastern Area and upset the movement of army in that region during the last World War.

In 1945-46 the Government of India seriously took up further investigation and appointed one of the TVA experts to formulate a scheme for prevention of flood in the area. This TVA experts, Mr. Voorduin, submitted a preliminary memorandum giving an idea of the magnitude of work involved and a very rough degree of the expenditure likely to be required in carrying out such a Project. The present Damodar Valley Scheme which has been taken up by the DVC is a part and parcel of the unified development as originally contemplated in Voorduin's Report. The scope in the case of some of the Projects under this scheme has however been very much enlarged to fit in with the requirement and demand of the people in general.

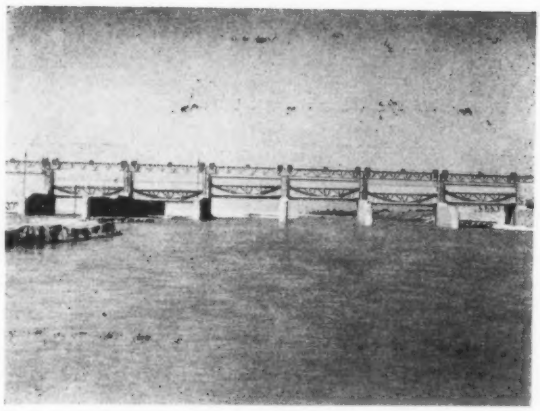
The Barrage & Irrigation Project is one of the various Projects of the entire scheme which has been now under execution by the Corporation and the maximum revenue to be realised to make this scheme paying is also expected from this Project.

Development of Barrage sites

Several Barrage sites were chosen to meet the demand separately for irrigation and also for irrigation and navigation together. Guhagram, which is below the location of the Anderson Weir at Rhondia, was the first to be considered as the best site for a Barrage for the Irrigation Project. Subsequently, it was proposed to increase the command on the Right Bank when the proposal of the remodelling the existing Anderson Weir at Rhondia was also examined. Theoretically it seems easy to use the Rhondia Weir in the new scheme after proper remodelling. But this weir has been damaged severely more than once. Its present condition is so uncertain that it will be unsafe to consider subjecting it, even after remodelling, to higher heads for obtaining greater command. In case of damage during the operation of the scheme, irrigation of the whole area would be upset.

When it was further decided to explore the possibility of combining irrigation with navigation in the Project as an additional feature, the Ranigunge site was given due consideration on account of its merit of being located adjacent to the Ranigunge Coal Field which could, then, be easily linked up with the Hooghly by means of a navigable canal.

The Coal Mining Association did not consider that such a barrage with a navigation canal at Ranigunge would meet the requirements of the local mining industry for the following reasons:



Damodar flowing through Barrage during Working Season 1954-55

(1) While the Ranigunge Coal Field despatched only a portion of the coal for Calcutta, an equal if not higher tonnage, is despatched from the Jharia Coal Fields located 30 miles upstream of Ranigunge. The navigation canal should, therefore, extend upto Jharia as well.
(2) Colleries are not as a rule situated on the river bank and hence so many feeder channels have got to be excavated extending right upto different coal-fields.
(3) The construction of ropeways as feeders does not seem worth considering the relatively small volume of coal that is to be carried over a distance of 10 to 12 miles.
(4) There would be a possibility of coal near the canal being locked up and also of sand for stowing the mines being more difficult to obtain.

Apart from what is said aboe there are very many reasons worth considering. The river conditions that are likely to obtain above the barrage after the construction of the dams, are not likely to make navigation possible in the river between the barrage and the Panchet Hill Dam except perhaps after sufficient time has elapsed and the river slope has flattened out. That is a contingency that may not arise for many years. Besides, the undulating terrain of the country precludes the possibility of the economic alignment of canals which will have to be carried in this part of the country by means of costly cross-drainage works.

The feeder canals will have to pass through the soil which would be porous and permeable and hollowed underground. Loss of water and percolation into the mines through the pores, fissures and cracks is a very serious possibility. A feeder system of canals, similar to Rly. siding, cannot, therefore, be visualised.

Nevertheless, the necessity of navigational facilities in the lower Damodar Valley has been grimly felt for

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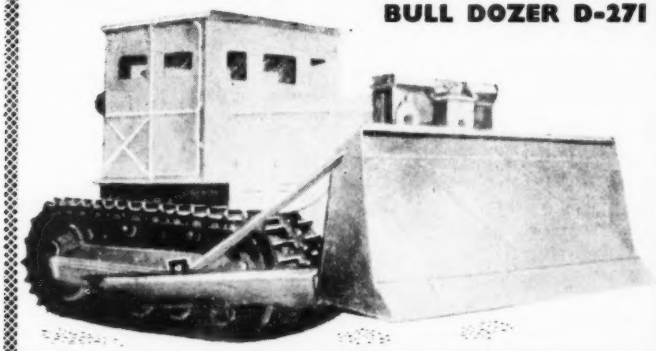

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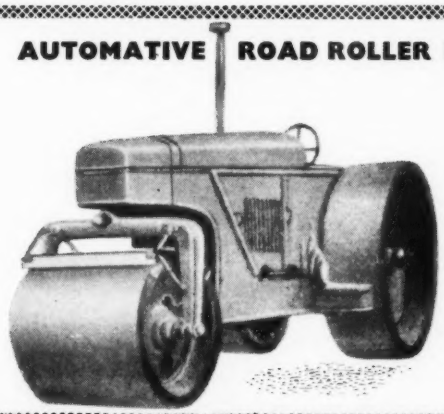

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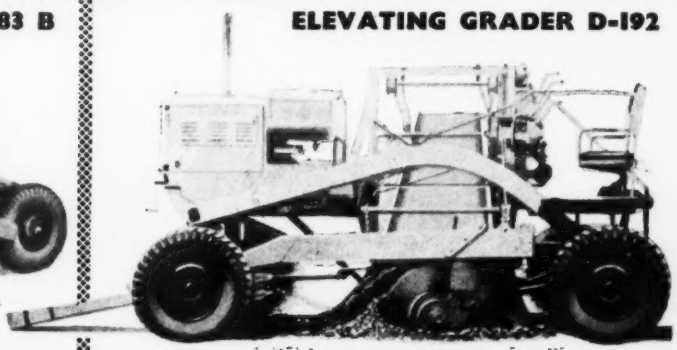

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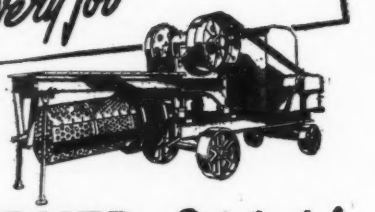

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more than fifteen years during which a system of priority allocation of wagons for traffic from industrial areas in Burdwan, Bankura and Manbhum to the Greater Calcutta industrial area had been in force. An alternative means of transport for diverting the coal traffic at least would be of positive advantage in an area, which has suffered from traffic congestion before, during and after the war.

Moreover there are many mills located on the banks of the river Hooghly starting from the proposed outfall of the navigation canal to Calcutta. These have got no railway sidings. Hence, it would be of distinct advantage to them to get the coal direct by means of barges. Water-borne coal in all probability will cost the consumer less.

What now remains of the Mining Association's objection is not that there should be no navigation canal at all but that it should not take off from Ranigunge. Besides, at the very outset it had appeared that a barrage at Ranigunge would be able to irrigate one lakh acres of land more than the remodelled Anderson Weir could be expected to do assuming irrigation on both the banks.

Investigations had shown that the cost of the Ranigunge Barrage would be excessive on account of long unproductive upper reaches of the canals in deep cutting and very costly cross-drainage works for the depressions. It was also found that it would be practically impossible to construct a right bank canal for irrigating the areas on the right bank. This was a very serious matter as the loss irrigable area threatened to be more than the gain that had been anticipated.

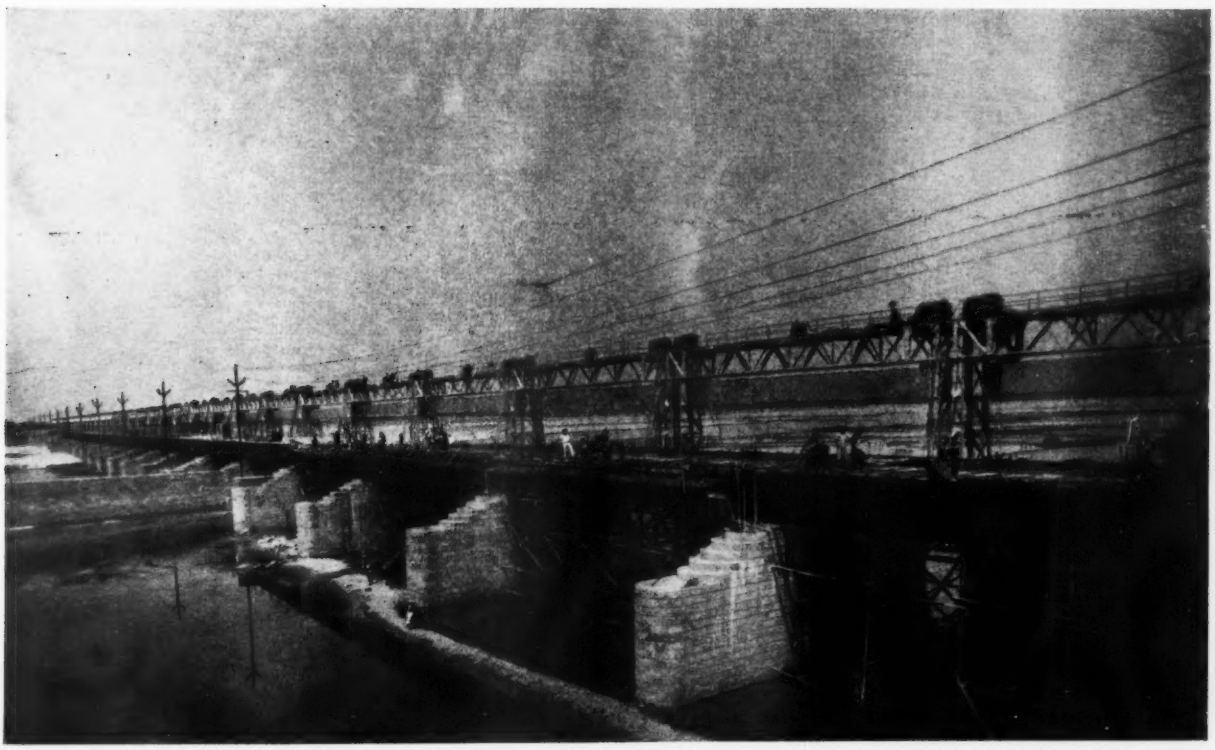
The coal field area near Ranigunge is already crowded. Moreover, the new factories, that are likely to develop would have to be built on hard and firm ground.

The Durgapur site has no such defects. Irrigation command on both the banks is well satisfactory. The solid ground on both banks for the barrage pool and subsequent development of industries will be available. Besides, it is clear of the coal field area by a safe margin. The pond will be sufficiently close to the coal fields to permit of the linking up of the collieries with the loading berths on its shores. To be brief, it is the highest point on the Damodar River whose all the factors are harmonised to maximum advantge.

Reasons for slow progress in the beginning

Though the site of the barrage was finally selected on 24th April, 1946, the progress of the work during 1948-1952 was practically nothing. Even before the Corporation formally came into being a Chief Engineer for the Barrage & Irrigation was appointed by the Government of India under the Administrator, Damodar Valley Project. He made some recommendations regarding the outline of the Project. These were however not accepted by the Corporation.

A view of the Barrage at Durgapur.



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Towards the earlier half of the year 1949 the Corporation as well as the then Engineer-in-Charge of the Barrage & Irrigation Project decided to change the idea of executing the canal works by manual labour to complete mechanisation. Some machineries were purchased but these could not be put to actual excavation of canals as the survey and design of canal system was then in an incomplete state.

Field survey was taken up but the supervisory staff selected for the preliminary work were not competent to deal with a scheme of this magnitude. This important subject was left to the surveyors who are irresponsible and ill-suited for the job. As a result most of the surveys were later found unacceptable and the designs had therefore to be changed and most of the works were fruitless.

At this stage there was hesitancy in taking up the construction of the barrage and purchase of machinery for the canals firstly for want of sufficient funds and secondly for synchronising the Barrage and Irrigation works with Maithon and Panchet Hill Dam works.

There was considerable delay in the sanction and appointment of a Special Land Acquisition Collector for the works. As there was financial stringency the entire sanctioned strength of staff was not even recruited. The entire year 1952 was spent mostly on exploratory nature of works. The necessity of a Special Land Acquisition Collector has been stressed by the Engineers since the very inception of the Project in view of the fact that the legal procedures entailed in acquiring the land for the purpose of the execution of the canals are very elaborate and secondly these are to be carried in order to cope up with the progress of the execution of canal works. But unfortunately this point was not given due consideration for too long a period to overcome the early set-back.

Thus not only the lack of fund but the lack of planning was one of the principal causes in holding up the progress at the earlier stages of the execution of the Barrage and Irrigation Scheme.

There was a feeling that the construction of the Barrage & Canals would be the last work in the DVC. In fact, the construction of canals should have been given higher priority over the Dam. The construction canal works, spread over in four districts is a problem in itsel . Unlike concentrated jobs e.g. construction of Dams etc. the canal works preclude the possibility of mobilising the labour and plant and machinery, materials of construction as and when required owing to the lack of approach to different sites and availability of reliable and suitable contractors. It is therefore always advisable to take up the canal works well in advance of the dams and barrages so that when water is ready for release the canals are also ready to convey the water to the fields. Unfortunately like many other Projects, in the DVC also, this aspect was overlooked.

Construction of Lock in progress

Central Design Organisation

Even as late as the end of 1952 there was no design organisation set up to complete the design works and formulate and standardise the principles of design.

Work of this magnitude naturally and necessarily calls for a detailed planning and complete designs of the various units of the entire system.

The planning and engineering work can only be done by a Central Design Organisation which deals with the following units:

(1) Planning of the whole scheme and preparation of the Project estimate and revision of estimates as and when required.
(2) Preparation of the schedule of rates and analysis of rates for the Project.
(3) Standardisation of designs of different structures e.g. bridges, falls and regulators, cross-drainage works etc.
(4) Directions regarding the collection of data.
(5) Interpretation and scrutiny of data sent by the field office.
(6) To keep ready the informations regarding the details of the scheme as regards planning and design.

At the planning stage a centralised organisation is beyond doubt a necessity. This, evidently, leads to the economy in design combined with speed which is very important in a Project.

At the initial stage the formation of the Central Design Organisation which is a prerequisite for a Project like this was not given serious attention. This has resulted in the delays in start of the work.

Construction Organisation

The Construction Organisation which is no less important in carrying out the work of such a great Project also necessarily demand proper selection of men for different type of jobs. As the Corporation had to start from scratch and could not get the help of

experienced personnel from the various States, right type of men with proper and suitable experience was not however put on the job. This bottleneck had considerably affected the progress of the work in the DVC. Even when personnel were selected they were taken on short term contracts and naturally the selected persons could not give their heart to the works. The Corporation's employees were always anxious to find out alternative employment of more secured nature and as a result the progress as well as the policy of the of the work have been very seriously affected.

A big Project demands from its different units a team-spirit and a team-work which, it is felt, was not forthcoming even upto the end of the year 1952. The consequences can hardly be emphasised.

Successful execution of the Project also demands:

(a) Proper guidance and direction from appropriate level.
(b) Homogeneous organisational set up.
(c) Prompt disposal and quick decision at all levels.

Selection of Machinery and Spare parts Contract versus Departmental Work

As the Corporation had no Co-ordinating Technical Head at the top in the beginning the selection of right type of machineries and purchase of spare parts did not receive as much close consideration as this subject deserves. This has no doubt resulted in accumulation of idle spares and machineries in the Project. A clear-cut policy regarding the mode of execution of works whether thrugh departmental machines or through outside agencies was not enunciated. One section was of opinion that the entire work should be carried out departmentally. The difficulties that are usually faced in taking up such major works departmentally and the economies of such works was not given much thought.

Since there was considerable delay in starting the works the original idea of employment of machines for a longer period thereby amortising their cost in the Project had to be abandoned. It was then found necessary to alter the plans of execution and the usual method of employing contractors on piece work contracts was resorted to. For excavation of canals, cotractors who had their own equipments were preferred.

Though the departmental method of execution may fit in with the present trend of nationalisation of industries or ideas of solcialistic pattern, the present unrest amongst the skilled labour, complete refusal by the Financial Experts of the introduction of bonus incentive amongst the employees makes the departmental execution definitely costlier apart from the obvious bottleneck in the matter of large scale employment. Another major defect in the departmental execution is the watch over unit rates and control over the cost. As it is difficult to estimate and combine all the various units of expenditure incurred in the departmental execution especialy when such work is carried out by machines, financial control becomes difficult and the estimates go higher and higher. It is also not always certain that Quality Control in case of departmental execution is more perfect. With the present financial rules and regulations, the hold up and idling of departmental works specially where such work is done through machines is very much more than that in the case of such works being executed through private sector where flexibility of accounts procedure

Lock Gate under construction by the side of G.T. Road near Burdwan.

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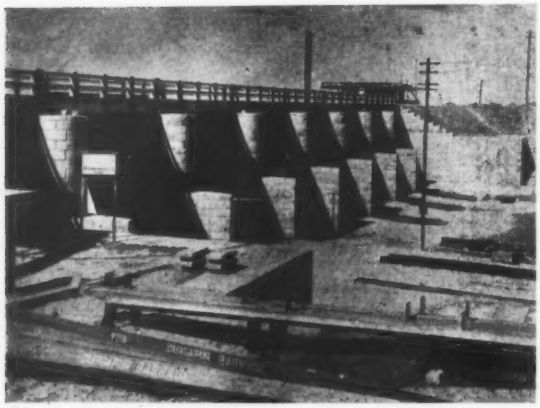

Left Bank Main Canal Head Regulator

and profit and loss account play most important part.

The method followed in the case of Barrage & Irrigation Project is a harmonius blending of departmental and agency execution which has enabled uptil now to keep a strict watch on the progress of expenditure. The significant increase in the basic price of construction materials, cost of labour and land is primarily responsible for boosting up the cost of the Project than that originally estimated. The scope of the Project having been enlarged to fit in with the subsequent request and demand of the beneficiaries naturally called for extension of works and increased expenditure.

Background and present stage of Progress

Though the Corporation came into existence since July, 1948 and the preliminaries for this Project taken up by the end of 1948, there has been practically no progress whatsoever till the working season of 1953. In fact even the survey of the canal alignment was not available.

Statement showing expenditure on B & I Project from July to June year by year is given below:

	Annual	*Cumulative*
July '48 to June '49	4,37,863	4,37,863
,, '49 to ,, '50	12,26,215	16,64,078
,, '50 to ,, '51	39,63,422	56,27,500
,, '51 to ,, '52	88,77,774	1,45,05,274
,, '52 to ,, '53	1,55,72,507	3,00,77,781
,, '53 to ,, '54	2,48,11,599 (approx.)	5,48,89,380 (approx.)

Expenditure incurred in 51-52 and 52-53 was not for works but mainly on account of purchase of machineries transferred to other Projects for want of design.

It will be apparent, therefore, that the Project has gained considerable momentum and if the present rate of progress is maintained there is every likelihood of the works being completed ahead of the of the Schedule.

With the time available for completion of the Project it is not possible to do the entire Canal works by the machineries available with us. It is not desirable to go in for fresh set of machineries for the obvious reasons that fullest use of the machines cannot be made and consequently the depreciation charges will be unduly higher. Manual Labour is cheap and available for Canal works in large numbers. There would, therefore, be no difficulty in completing the works within the Scheduled programme through the agency of the contractors.

Development of Irrigation would take some time and it would, therefore, be desirable to phase the Capital works in such a way as to keep pace with the gradual development of Irrigation.

The above picture is not a real indication of the progress that could be made with the present set up as this project is being seriously handicapped for want of timely possession of land. Cases are not few when the Contractors could not take up work for want of land though contracts were finalised in anticipation of receiving possession of land. It takes 10/12 months to receive possession of waste and arable land after the requisition is sent and in the case of tanks, homestead etc., the time lag between delivery of possession and requisition is even very much longer. The actual progress would be very much more if the land acquisition difficulties could be overcome.

The up-to-date progress of work in the Barrage & Irrigation Project is quite satisfactory in view of the fact that the progress of work has had an earlier set back too severe to overcome.

The construction of the barrage is nearly complete. Amongst 34 bays of the barrage 24 weir bays and 5 left and 5 right undersluice bays i.e. all the 34 bays have been completed. The erection of gate is nearing completion.

In Canal works the following table will indicate the measure of progress achieved against heavy odds:

Earth-work in	*Estimated Quantity* (Crores Cu. Yds)	*Completed upto end of Jan, '55* (Crores Cu. Yds)
Main Canal	2.15	0.7
Branch Canal	0.93	0.4
Distributaries	1.67	0.36
Navigation	0.44	0.11
Drainage	0.93	0.16

There are altogether 2000 numbers of structures out of which 100 numbers are complete and 200 numbers of structures are under construction. It is expected that some more structures may be taken up before next rains.

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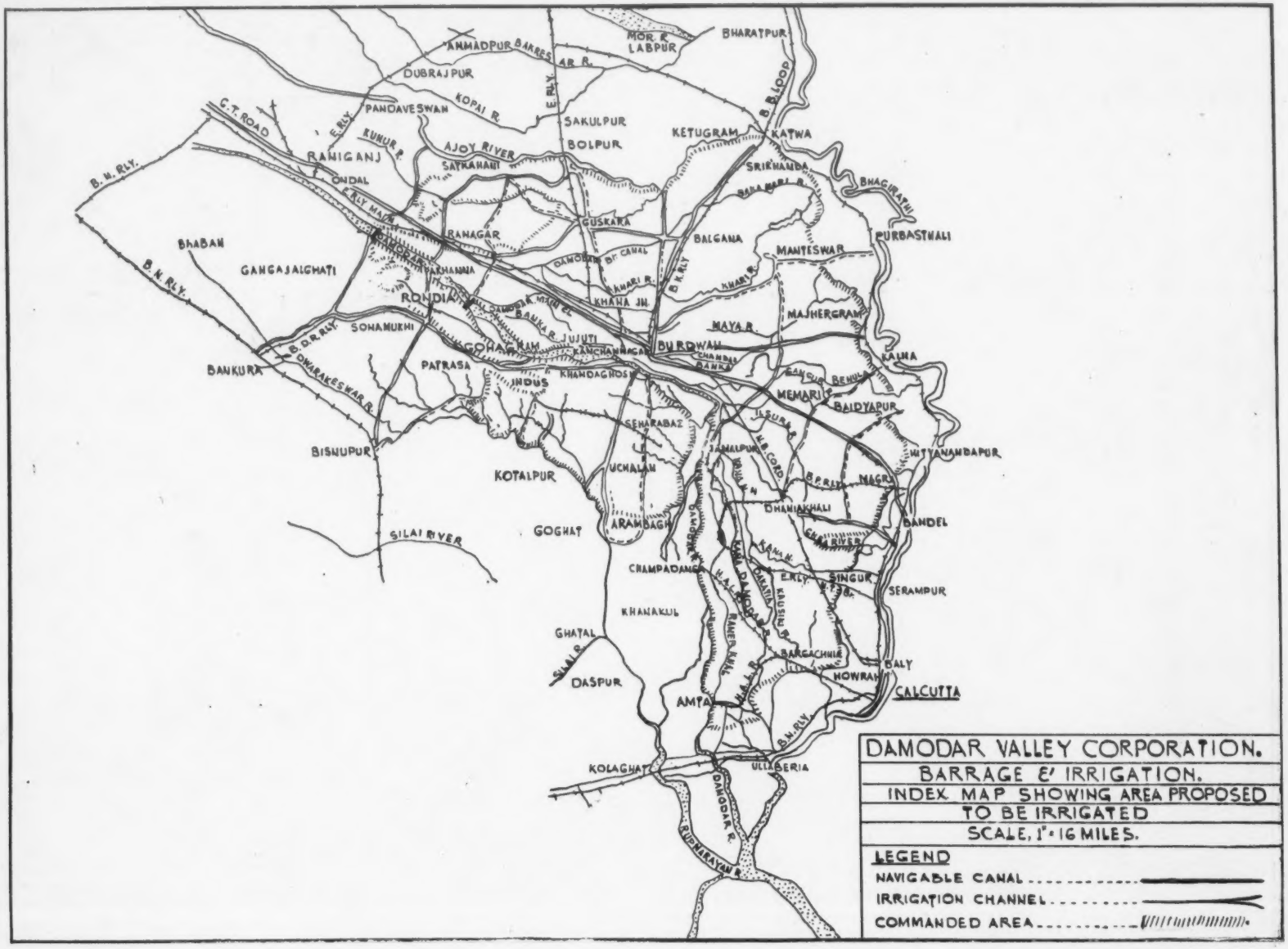
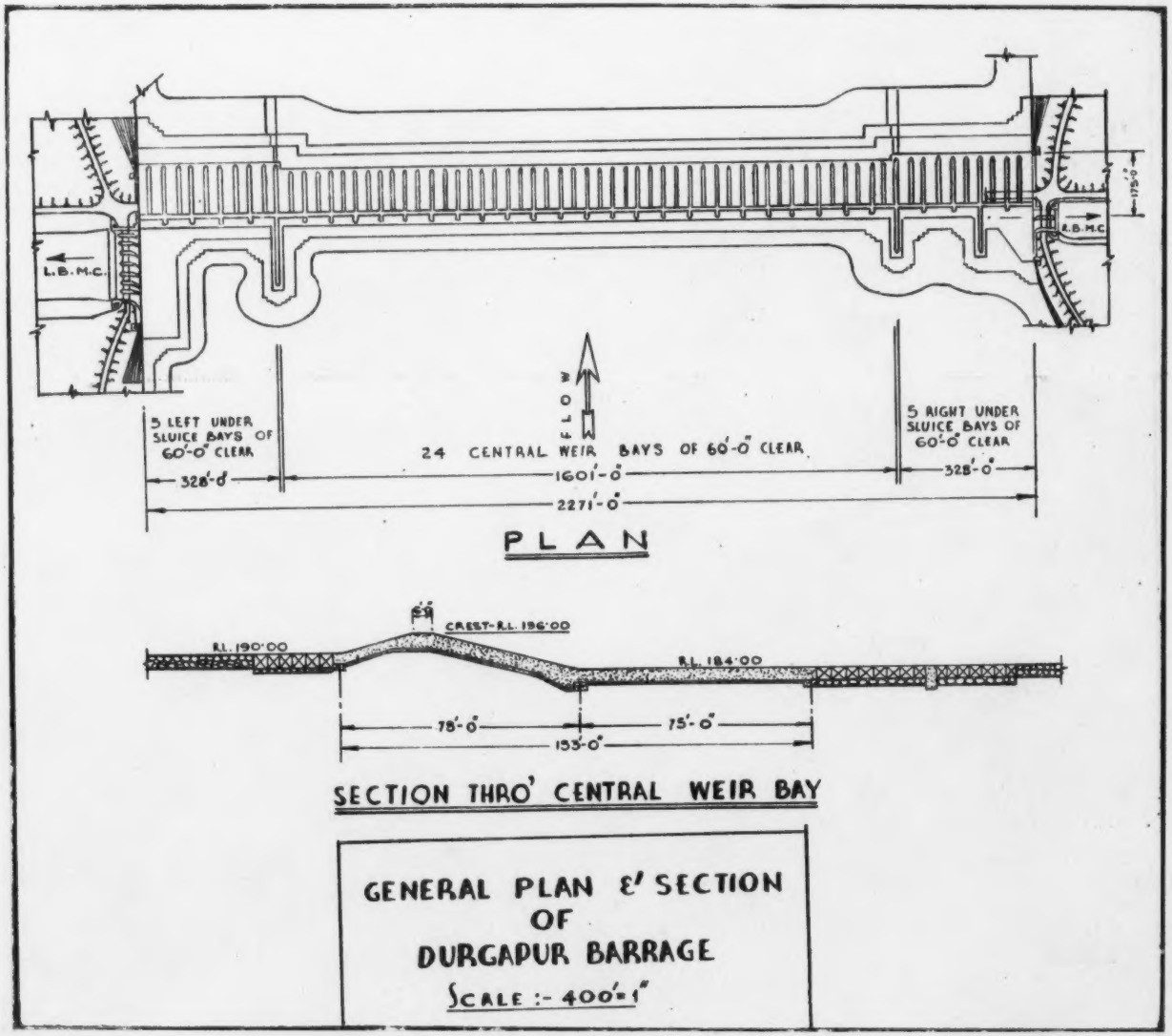
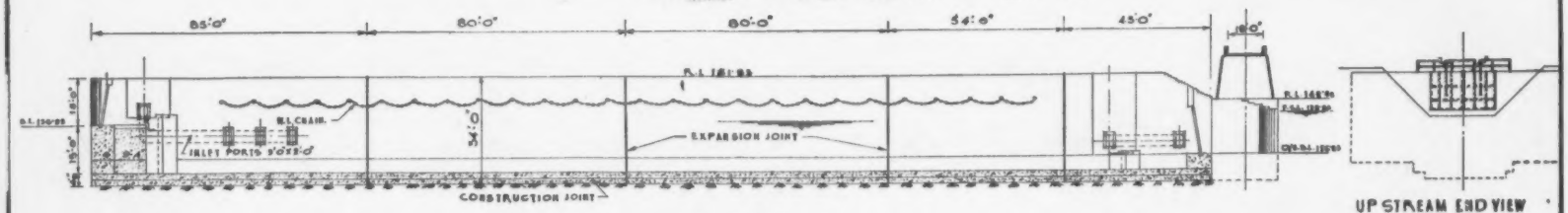
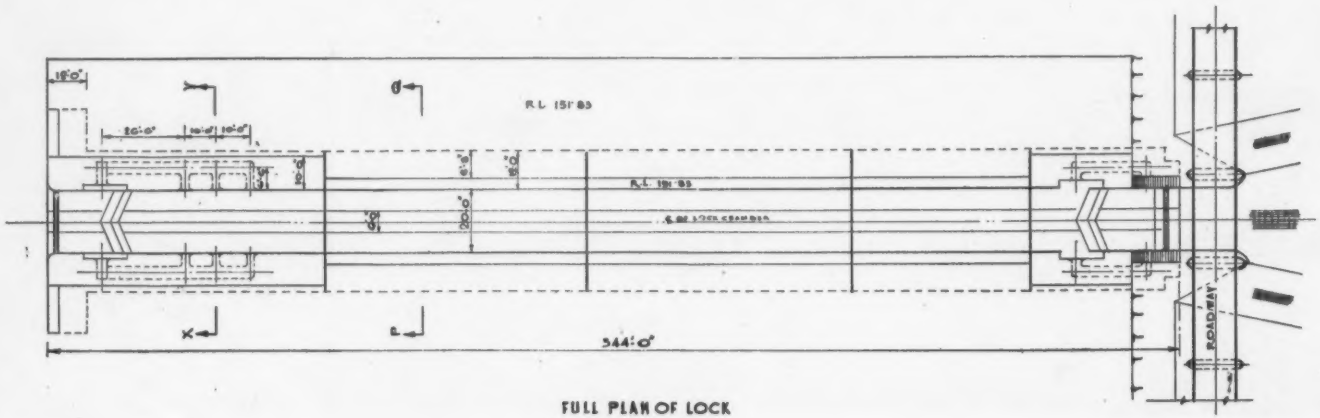

DAMODAR VALLEY CORPORATION.
BARRAGE & IRRIGATION.
INDEX MAP SHOWING AREA PROPOSED TO BE IRRIGATED
SCALE, 1" = 16 MILES.
LEGEND
NAVIGABLE CANAL
IRRIGATION CHANNEL
COMMANDED AREA
BHARATPUR
MOR & LABPUR
ANMADPUR BARREG
AR R.
DUBRAJPUR
KOPAI R.
PANDAVESWAR
E.RLY.
SAKULPUR
BOLPUR
KETUGRAM
KATWA
B.B.LOOP
C.T.ROAD
KUNUR R.
AJOY RIVER
RANIGANJ
SAINHATI
SRIKHANDA
BHAGIRATHI
B.N.RLY.
ONDAL
E.RLY MAIN
BARAKAR R.
PURBASTHALI
BHABAN
GANGAJALGHATI
RANAGAR
GUSKARA
BALGANA
MANTESWAR
DAMODAR CANAL
KHARI R.
B.K.RLY
KHARI R.
KHANA JN.
MAJHERGRAM
RONDIA
SALANPUR
BANKA R.
MAYA R.
SONAMUKHI
B.D.R.RLY
JUJUTI
GOGHAGRAM
KANCHANNAGAR
BURDWAN
CHANDA
BANKA
KALNA
BANKURA
DWARAKESWAR R.
PATRASA
INDUS
KHANDAGHOSH
GANGUR
BEHUL
MEMARI
BAIDYAPUR
SEHARABAZ
JUNAI R.
BISNUPUR
JAMALPUR
M.B.CORD
MITYANANDAPUR
KOTALPUR
UCHALAN
KHANAN
B.P.RLY
NAGRI
DHANIAKHALI
BANDEL
ARAMBAGH
GOGHAT
SILAI RIVER
CHAMPADANGA
KANA R.
DAMODAR
HALDI R.
KANSIA
KANSIRI R.
E.RLY
SINGUR
B.P.RLY
SERAMPUR
KHANAKUL
GHATAL
RAMEKANALI R.
BARGACHHIA
BALY
HOWRAH
SALI R.
DASPUR
AMTA
KANA R.
CALCUTTA
B.N.RLY
KOLAGHAT
ULUBERIA
DAMODAR R.
RUPNARAYAN R.


L.B.M.C.
R.B.M.C.
5 LEFT UNDER SLUICE BAYS OF 60'-0" CLEAR
24 CENTRAL WEIR BAYS OF 60'-0" CLEAR
5 RIGHT UNDER SLUICE BAYS OF 60'-0" CLEAR
328'-0"
1601'-0"
328'-0"
2271'-0"
N
PLAN
CREST-R.L. 196·00
R.L. 190·00
R.L. 184·00
78'-0"
75'-0"
153'-0"
SECTION THRO' CENTRAL WEIR BAY
GENERAL PLAN & SECTION
OF
DURGAPUR BARRAGE
SCALE :- 400'=1"



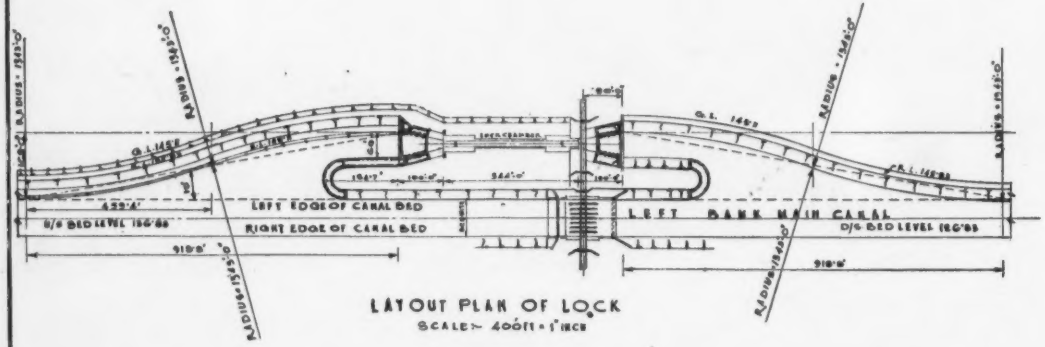
SECTIONAL ELEVATION OF LOCK

UP STREAM END VIEW



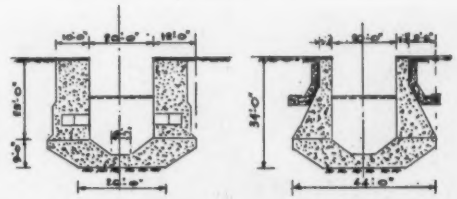
FULL PLAN OF LOCK

SCALE:- 50'ft = 1 INCH.



LAYOUT PLAN OF LOCK

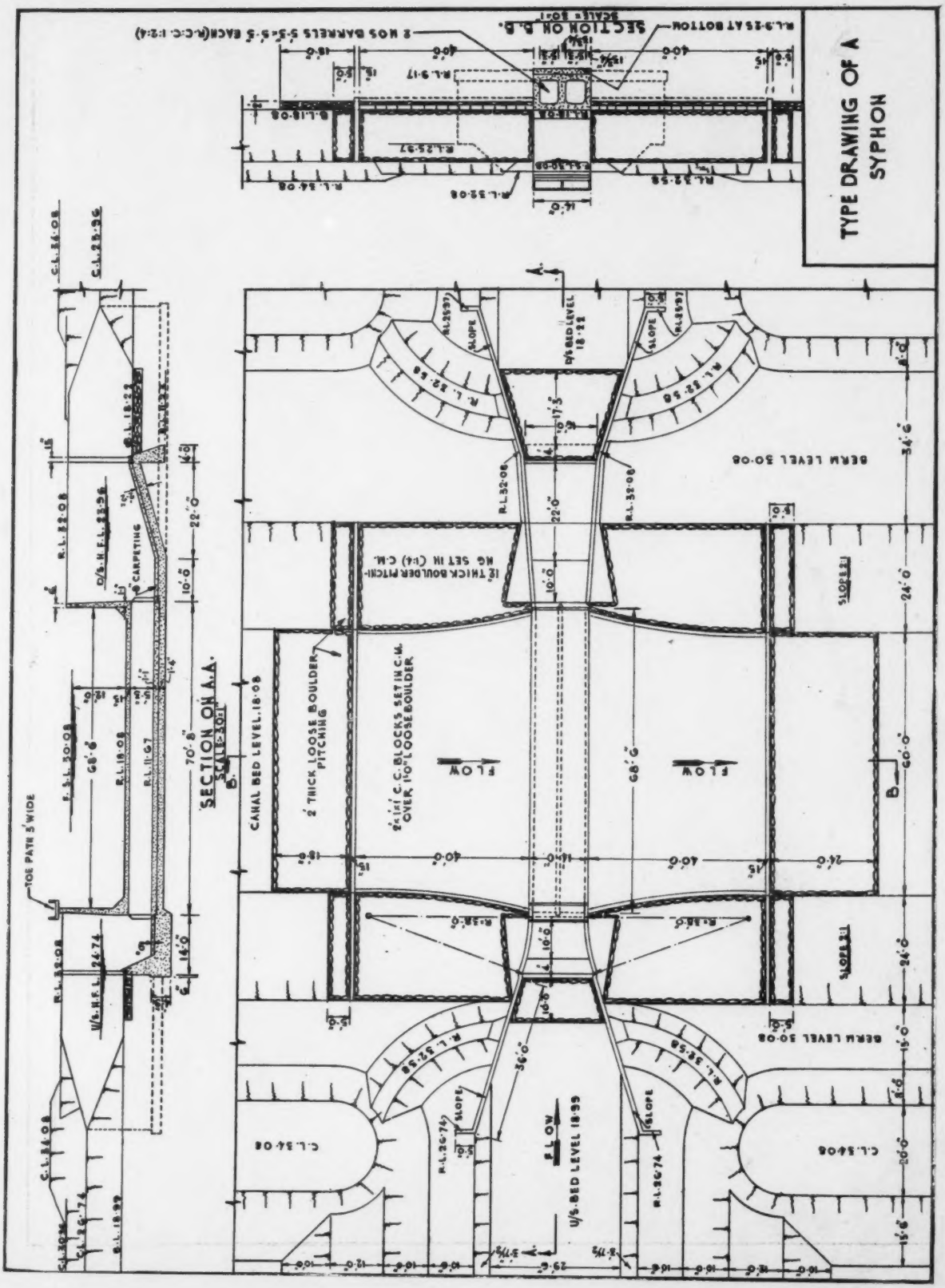
SCALE:- 400ft = 1 INCH



SECTION ON XY.

SECTION ON PQ.
(GATE REMOVED)

A TYPICAL LOCK CHAMBER WITH LAY OUT	
MATERIAL — MASS CONCRETE	SCALE:- 50ft. = 1 IN. & 400ft. = 1 INCH.


TYPE DRAWING OF A SYPHON
SECTION ON P.P.
SECTION ON A.A.
CANAL BED LEVEL 18·08
2' THICK LOOSE BOULDER PITCHING
FLOW
BERM LEVEL 30·08
SLOPE
TOE PATH 5' WIDE
CARPETING
C.L. 34·08
U/S. BED LEVEL 18·99
R.L. 32·08
R.L. 22·08
R.L. 18·08
R.L. 11·07
22'-0"
40'-0"
68'-6"
70'-8"

The construction of locks for the purpose of navigation are proceeding with a good pace. Nearly 18 nos. of locks out of 22 are complete. The progress of the Navigation Canal also is quite good and I feel that the navigation canal will be ready for operation in time.

Utilisation of Water

With the gradual completion of the storage reservoirs, Dams and diversion systems, the question to accelerate optimum utilisation of water has gained paramount importance. The fundamental factor which governs speedy utilisation of the water for irrigation purposesis more socio-economic than anything else. The dem and of water for irrigation purposes depends by and large on the following factors:

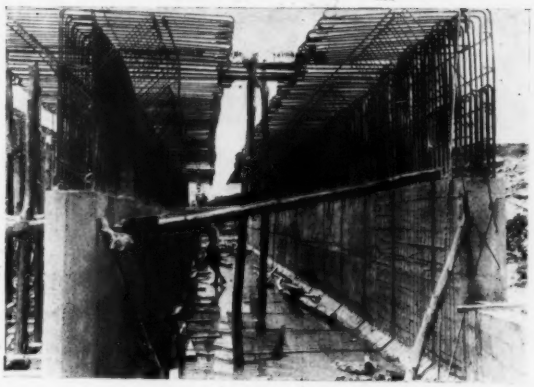
(a) Change over to a new system from the age old practices.
(b) Speedy remodelling of the agronomic pattern.
(c) Economic results of such changes.

So far the agricultural practices have depended more upon nature. The prevalent method of cultivation in our country requires definite improvement on modern lines. Ignorance and poor economic condition are the prime causes of the deterioration of the agrarian economy.

As soon as irrigation water will be ready for supply the farmers are to take initiative for double or treble cropping which will be easier if the cultivators may know where and when the different crops are to be cultivated.

With the existing purchasing power of the Indian farmer it will be extremely difficult for him to purchase manures and chemical fertilisers and good varieties of seeds, all of which have got to be supplied by the Government to the farmers at subsidised rates for the first few years.

Extension of Co-operative movement and starting of Co-operative farms would certainly be very helpful in the matter of distribution of water, utilisation of water, raising one or two crops from the same field, arrangement, collection and distribution of manures and seeds etc.



Aqueduct under construction on Banka River, Burdwan

The existing communication facilities also in the Indian villages are hardly suitable for cheap and easy transport of the manures and fertilisers to the fields and of the additional produce from the fields to the market. It is, therefore, only complementary that means of communication will have to be improved in these areas.

The present system of betterment levy and water rates should, I feel, have to be re-adjusted in accordance with the slab system of taxation method. It may also be considered whether the water rate and the betterment levy rate may be completely waived or a nominal rate should be assessed upto a limit of certain area and thereafter the rate of assessment can be correspondingly enhanced with the gradual increase of the size of holdings.

Conclusion

In conclusion I would like to emphasise that it should not be overlooked that in one important respect the DVC's approach to the irrigation problem is completely different in its technique. The DVC cannot remain self-complacent by supplying water only to the fields. It will have to concentrate its efforts in order to accelerate the utilisation of water in the valley for the double reason that, as a business undertaking, it must look after its own profit and loss account and, as a public Corporation, it assumes a statutory obligation for promoting social and economic welfare in the area.

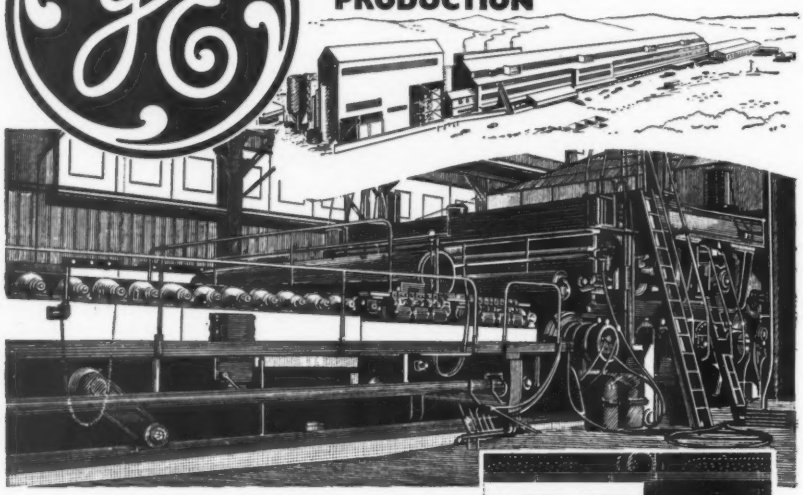
Continued from page 46

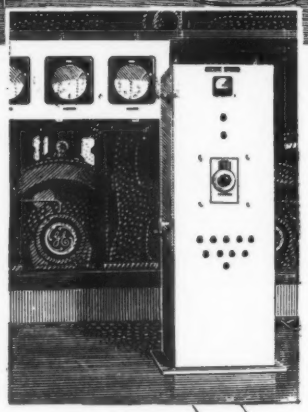
Maithon Underground Hydro-Electric Power Station

Calcutta system through a receiving station with three 55 MVA transformers and three 20 MVA synchronous condensers. This will raise the combined DVC-Calcutta system capacity to 604 MW. Demands for additional loads are coming in and the Calcutta Electric Supply Corporation have already proposed the installation of an additional 50 MW set at their New Cossipore Station. As any power system cannot remain static, the Corporation has plans for building additional hydro-electric plants at Ayyar and Bermo on the Damodar and at Balpahari on the Barakar. These new hydro stations and additional load growth might justify another super steam station in the Valley. This programme may have to be accelerated if the third State-owned Steel Plant is located in the Valley.

(Acknowledgement: Valuable assistance was given by Messrs S. B. Deb and K. Ramanathan, Asst. Project Engineers, which is gratefully acknowledged).

ELECTRONIC CONTROL FOR NEPA NEWSPRINT PRODUCTION





India will soon be able to meet one-third of her requirement of newsprint when the Rs. 6-crore Nepa Mills goes into full production in a few months time. The only one of its kind on the mainland of Asia, six electronic controlled drives of Nepa Mills will turn, abundantly grown *salai* and bamboo of Madhya Pradesh into useful newsprint playing a very important role in the development of the country's press and literacy.

The quality and production of paper calls for very critical control of the paper machine drive. The G.E. Electronic Amplidyne Control installed at Nepa Mills will enable one operator to co-ordinate all six groups working at the same time. This highly accurate and modern G.E. drive system is being used by leading paper mills in the United States, Canada and Europe.

Using G.E. Electronic Amplidyne drive system, it is estimated that enough paper in a sheet 18 feet wide could be produced in 24 hours to cover the 327 miles from Nepanagar to Bombay.

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353

Public Power Supply Business

K. SUBRAMANIAM

The power programme of the Damodar Valley Project has been a subject of controversy in many quarters from time to time. This contribution from Mr. Subramaniam, who is handling its economic and commercial aspects from the very beginning gives an authoritative view of the situation as it stands today. One thing stands out quite clearly, namely, that the demand for electricity in the region is overwhelming and it will soon be a problem for the DVC to keep pace with it. Still another is that DVC's major responsibilty is bulk generation and bulk distribution. It is no part of DVC's responsibility to promote or arrange distribution to small consumers—it is the States'. The author also discusses whether the cost of electricity so generated is "cheap" or not.

AUTHOR

In 1951 the total investment in the business of electricity supply stood at about Rs 148 crores, of which Rs 78 crores represented public capital and the remainder private investment. During the First Five Year Plan period the expenditure on Power System development undertaken by Governments alone is of the order of Rs 225 crores. This is a sizeable investment, and Public Electricity Supply in India, as elsewhere, is tending towards "big business".

It is also something more than just "big business"; it is in addition, a vital public utility service. To ensure rapid expansion of this service and to make it available over a wide area, power development on a regional basis (as distinct from plans confined to urban and semi-urban limits as in the past) becomes a necessity. Such development does not lend itself easily for private exploitation and the public cector perforce will be called upon to take up continuously increasing shares of the investment in Public Electricity Supply.

The DVC has been entrusted with the task of large-scale power generation and distribution in the Damodar Valley and adjacent regions. The investment on Power by the DVC will be of the order of Rs 58 crores.

The total installed capacity, when the installations in the first stage of the Project are completed, will be 344,000 kWs comprising of :

1. Bokaro Thermal Station ..	200,000	kW
2. Maithon Hydro Station ..	60,000	,,
3. Panchet Hill Hydro Station ..	40,000	,,
4. Konar Hydro Station ..	40,000	,,
5. Tilaiya Hydro Station ..	4,000	,,

The power generated at the above installations will be distributed through a transmisson system comprising 723 miles of 132 KV and 96 miles of 33 KV transmission lines, 12 Grid Substations and a number of 33 KV receiving stations. The system will then be capable of handling a total load of 284,000 kW and cover an area of 35,000 sq. miles from Calcutta in the east to Dehri-on-Sone in the west, and from Jamshedpur in the south to Patna in the north.

The two power stations completed so far—the Bokaro steam station and the Tilaiya hydro station—with an initial installed capacity of 150,000 kW and 4,000 kW respectively went into commercial operation in 1953. The Tilaiya station is already fully loaded (with a maximum demand of 2600 kW). Owing to certain initial difficulties and delays in the deliveries of equipment, the transmission system could not be got ready earlier, with the result that the load on the Bokaro station has not yet exceeded 45,000 kW. Now practically all the delays have been overcome and very shortly the Bokaro station will carry its full load. This initial setback is only a temporary phase and is by no means an indication of the power demand in this area, as will be clear from the following.

The Corporation has already entered into a number of agreements for supply of power. The aggregate total of these contracts amount to 113,000 kVA. Further notified demands of the consumers with whom contracts have been signed add upto another 114,000 kVA. In addition, the Corporation is negotiating further contracts with various parties and has given them an undertaking to supply a total of 132,000 KVA. The total load for which the Corporation is committed amounts to 358,000 kVA which would represent a system demand of about 267,000 kW.

The anticipated load growth as well as the programmed increase in the firm capacity of the system is shown below:

	1955-56	56-57	57-58	58-59	59-60	60-61	61-62
Firm Capacity (MW)	126	60	197	247	284	284	284
System Demand (MW)	80	106	136	192	222	249	274

It will be seen from the above that it is planned to effect a fair degree of co-ordination between construction of facilities and the demand of power.

K. Subramaniam, M.E, A.M.I. E(Ind.) *is Commercial Engineer, Damodar Valley Corporation.*

Apart from the loads taken into account so far, there are other prospective demands like the aluminium industry at Asansol, new steel plant in the Damodar area, further expansion of the Tata Iron & Steel Co. and Indian Iron & Steel Co., extension of the Sindri Fertilizer Factory, requirements of the Indian Copper Corporation in Ghatsila area etc. The need for a continuous plan of expansion is therefore obvious.

Power from the DVC is being used and will be largely utilised for the development of basic industries in the region served, particularly for the existing steel plants and their expansion, the mining and refining of copper, extraction of coal, production of aluminium etc. Availability of a plentiful supply of power has also assissted in the establishment of new industries like loco-motive works, Cable factory, Bicycle manufacture, Glass Works, etc. in this area. Another important development made possible is the proposed electrification of the Eastern Railways from Howrah to Burdwan immediately and to Mughalsarai in stages in due course.

The impression might be created that the DVC caters only for large industries; it is not so. In an area like that served by the DVC which is considered the "Ruhr of India", industrial expansion is bound to be predominant. Also, by virtue of the DVC Act, the Corporation is authorised to sell power in bulk only. Although this results in a large percentage of industrial consumers, bulk supply of DVC power is being given to a number of distributing licensees as well as to the State Governments at a number of points to enable them to distribute power in a large area for rural development. The Government of Bihar is already taking a supply at 4 points and intends to avail itself of the DVC power in a number of additional places for retail distribution and they have plans to spend more than a crore of rupees for this purpose. Similarly the West Bengal Government have plans for distribution of DVC power over a wide rural area. Thus the DVC project is designed to assist in every phase of economic development of the region.

While the DVC can provde some of the vital requirements like power for rapid development of industries, the actual development and the consequent full utilisation of the DVC power will obviously depend largely on other factors. For instance, it is believed that the expansion of the steel industry in the Valley, although recognised as deserving high priority, has been delayed for several years owing to uncertainties of policy. The collieries in West Bengal and Bihar which raise more than 90% of India's coal and which have in use over 98,774 HP of old steam engines and other uneconomic installations appear to be hesitant to invest further capital for modernising their equipment that in the long run will effect economies due to apprehension regarding their future. A clear-cut declaration of policy in respect of each industry, not merely as regards the ultimate ideal but in terms of time and manner of adjustment, if any, as between the agencies in the field is believed to be necessary, if development is to proceed apace.

Another factor which has greatly influenced not only the construction of the facilities but also the utilisation of power is the availability of heavy electrical equipment. Experience has shown that complete dependance on foreign countries for the supply of equipment could cost the nation heavily both in money and time. The proposal to manufacture heavy electrical equipment in the country was mooted nearly ten years ago; it is hoped the project will materialise without further delay and solve one of the major problems in planning development.

While the DVC could cater directly to the needs of large industries, it serves the small-scale industries and rural area mainly through the medium of State agencies. Here the pace of development naturally depends upon the resources and keeness of the State. There is abundant evidence to show that these agencies are planning on a large scale to bring the amenities of electricity to all parts of their area. But the growth of the use of power by the householder or the agriculturists will depend largely on the tariff and taxation policies of the Government. While on the one hand Governments spend large amount to distribute electricity in the rural areas, on the other hand they impose a tax in the form of Electricity Duty, some times as much as 25% of the cost, on the primary use of electricity by the masses, viz: domestic service. This is bound to have a restrictive effect on the use of electricity in the homes and to that extent would deprive the householder of the amenities that could otherwise be enjoyed by him. A general review of the policy of taxation on electricity consumption would be timely in the context of the large power projects now under way.

Projects like the DVC have a direct interest in all these matters. Their prosperity and, one may say, even their justification requires the removal of all factors that stand rightly or wrongly in the way of full utilisation of the resources developed by them.

A term that is frequently used but seldom defined in connection with power projects is "cheap electricity". At best it can be a comparative term. There is a tendency to compare the cost of power from projects now under way with that from older power systems constructed before the war and feel disappointed when the present-day power cost is higher. A little reflection will show that this is not justified. As a general rule, compared with prewar levels, the cost of equipment has gone up 300-400%, wages cost 250% and fuel between 250-300%. The use of modern equipment and technique in the production and distribution of power has, however, made it possible to effect economies to largely offset these abnormal increases, and generally speaking, the increase in the cost of the end product viz: electricity, has been less than 50%. When the cost of the product reflects only a small fraction of the increase in costs of the various elements that

go into production, perhaps one may be permitted to claim it as "cheap".

Another way of looking at it will be to see the effect of the cost of electricity on the industries. Excepting in the case of large electro-chemical industries, the cost of power forms only a small component of the total cost, anything between 3% to 5% increase in the cost of power would mean an increase of 1.5% to 2.5% only in the cost of the finished product. Considering the fact that wages, equipment costs and other major items of the industry would have registered simultaneously an increase of anything between 150 to 300%, the change in the price of electric power would be practically of no effect. The emphasis, as far as industrial development is concerned, would therefore appear to be not so much on the cost of power but its availability in large quantities in potentially industrial areas.

A public owned utility like the DVC carries with it somewhat greater responsiblilities than a private undertaking. The objective is not limited to the earning of an adequate return on the heavy capital investment. It becomes equally important to provide a supply of power wherever it is needed, although the extension of the service to certain areas might not, prima facie, appear prudent by ordinary tests of profitability. It may be said that the aim should be as extensive a service as possible on a "no-loss" basis, rather than the earning of an attractive return on capital.

The main objectives of a public agency running a large power system should be :

(1) production of electricity as economically as possible,
(2) making electricity available in every part of its operation area,
(3) managing the undertaking in such a manner that taken over a period of years no losses are incurred in its operation, and thus avoid a recurring drain on the tax-payers' money.

This calls for a management that is not only efficient but also enlightened; hence the concept of statutory bodies, not tied down by either governmental rules and routine or the demands for profit by the investor, as a suitable form of agency for management of regional public utility systems.

The extent to which the agency makes electricity available in adequate quantities and at economical prices will be a measure of its efficiency. The extent to which it is prmitted to function towards that end will constitute an index of the enlightenment of the governments controlling such statutory bodies.

Continued from page 36

Panchet Hill Projects

the resources available would be utilised for the construction of Colony, Workshop, Hangar, Access Roads, Transmission Lines and other ancillary works for the Project including procurement of stores. As other projects get completed all available resources of technical personnel and stores will be released for the main work during subsequent seasons. This planning is not however fully realised in practice.

It is scheduled that all the main works in connection with the dam as well as the Power House including installation of gates, electrical and mechanical equipment, switch yard and substation will be ready by the the end of working season of 1957.

Phasing of works

At the site of the dam the river flows a very long bend outwards (towards the right) having a tendency to flow along the right bank and during latter part of winter and spring, the flow is confined to a channel about 300 ft. wide along the right bank and the rest of the width of river channel remains dry. The diversion channel cuts across this projection on the left bank forming a chord across the arc formed by the river. In consideratin of the above factors and owing to inadequacy of equipment available in the first seasons, the work have been phased so as to be completed in 1956-57 starting from 1952-53 season.

Progress of work

Progress achieved to the end of January 1955

(1) Diversion channel	Excavation common soil	4,73,463	cuyds
(2) Earth Dam	Excavation rock	5,92,940	,,
(3) Dykes	Rolled fill	15,16,268	,,
(4) Concrete Dam	Excavation common soil	33,639	,,
	Excavation rock	1,19,713	,,
	concrete	22,312	,,

The sanctioned estimated cost of work is 13,38,26,000. The expenditure incurred to the end of December 1954 is Rs. 3,95,62,660/-

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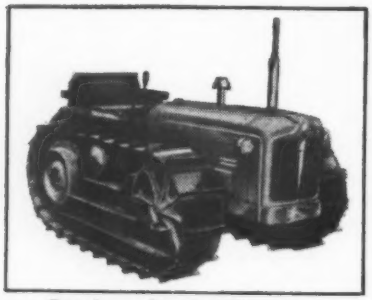
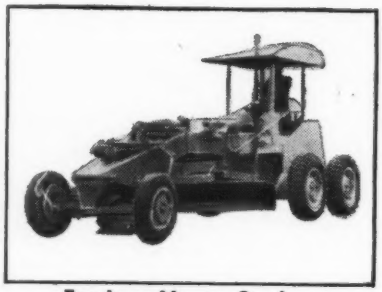


Fordson County Crawler

Fordson Chaseside Dumper



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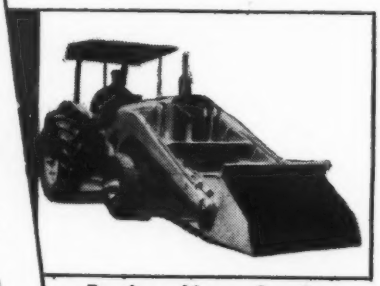
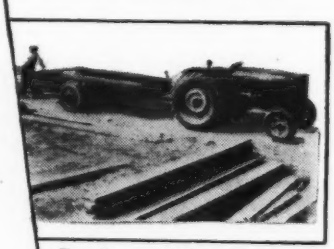
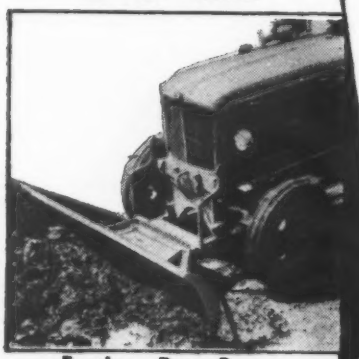


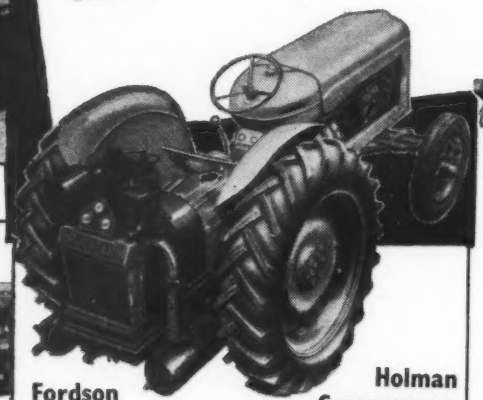
Fordson Moore Loader



Fordson With Trailor



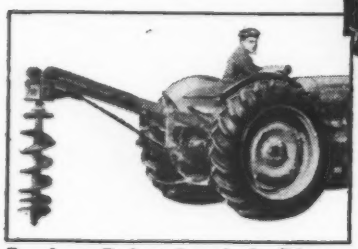
Fordson Bray Dozer



Fordson

Holman
Compressors

Fordson Moore Crane



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Mechanised Earth-Moving for Development

S. S. PILLAI

This is a subject whose importance is growing with time. With increasing emphasis being given to soil conservation, it is quite natural that mechanical earth-moving will become more popular. It is therefore fitting that the DVC lay great emphasis on this aspect of the work in its construction program even risking misunderstanding among many. Now it is slowly being realised that early establishment of the Soil Conservation Department by the DVC and its consequent rich experience has given a much-needed lead to the country and has greatly focussed public attention on the problem of soil erosion. The following contribution summarises the experiences gained by the Mechanised Earth Moving Circle of the S. C. Department, which should prove of value to other river valley authorities as well as to the departments of Agriculture in the States. It will be noticed that the Circle has proved to be of considerable help to the DVC in many ways which were not expected of it at the time of its inception.

AUTHOR

Construction with the aid of mechanical equipment has come into vogue in recent years, more after World War II. Progress in production, either for military or civil purposes, has normally accentuated the necessity and the military demands created a great urge for speeding up production.

Planning and programming the various aspects of construction procedure and equipment are essential basic needs of modern construction and these have developed a process of organised plant layout, equipment and workshop on the basis of the primary factors involved. Improvement in design of equipment to suit varied conditions and purposes has extended the scope of such work, making it possible to undertake any construction by mechanical means.

Equipment and Selection

It is important that the most efficient types of equipment have to be selected for different works to obtain the maximum efficiency and output. This depends on working conditions, materials to be handled, arrangements for disposal of excavated materials, haulage distances, borrow areas, blasting facilities, etc. Each project has to have special data as all the printed data available can only be considered as averages.

The above principles apply also to the selection of used equipment, as consideration is to be given for the residual value of equipment. Particularly in this country, where manufacture of spares of heavy equipment has not yet commenced, and the shortage of skilled men for operation and repairs is still acute, it is far from advisable to begin any project with used equipment.

Other aspects to be considered in the selection of equipment are the sizes and standards of equipment. Smaller jobs must almost always depend on smaller and standard equipment. This will save capital costs and maintain efficiency and uniformity in output. As far as practicable similar types of equipment with multi-purpose duties are to be preferred on all jobs and this will facilitate maintenance, supply of spares, etc. Suitable selection of equipment has also to be based on a balanced running of excavating and hauling equipment with due consideration being given to hourly output of individual equipment, as excavating seldom gives the maximum efficiency due to varying factors.

S. S. Pillai *is Superintending Engineer, Mechanised Earthmoving Circle, Soil Conservation Department, Damodar Valley Corporation.*

Formation of the Circle

The Mechanised Earth-Moving section was formed in 1949 under the Soil Conservation Department, D.V.C., as an entirely self-supporting section for all operations covering works from reclamation of wasteland to building small dams for irrigation, carrying out earth-work urgently for other projects of DVC and other miscellaneous works from time to time for outside agencies, such as Bihar Government and others. In order that the entire cost is covered by certain specific economic unit rates, the section was organised with the minimum of staff to give maximum efficiency. Machines had to be operated to their optimum capacity for economic output. Due to the shortage of trained staff in the country it was a problem of its own and it was even more difficult to get people with experience in wasteland reclamation of the type involved in this Corporation. Recruitment and training of Engineers, Mechanical staff and Operators was a major problem until late 1951. The staff so trained proved also very useful for other projects of DVC later.

Equipment

The equipment, to begin with, was a reconditioned Caterpillar D-7 tractor with a bulldozer and scraper attachment and two Minneapolis Moline tractors with mould-board plough attachments. Reclamation of wasteland was the initial work of this section.

Major portion of the remaining equipment was received at the end of 1950. Total equipment of the Circle is as follows:

Allis-Chalmers HD-19, HD-10 and HD-5 tractors	21 Nos:
Caterpillar D-7 tractors	11 Nos:
International TD-18 and TD-14 tractors	8 Nos:
D-Roadster Tournapulls ..	12 Nos:
Allis-Chalmers TS-300 Scrapers (LaPlant Choate)	3 Nos:
Ruston Bucyrus 54-RB Draglines 2½ Cyds. capacity ..	2 Nos:
Hanomag tractors. ..	4 Nos:
International WD-9, WD-6 and M.M. wheel tractors	6 Nos:
Austin-Western 99H Motor Graders ..	2 Nos:

There are in addition other miscellaneous equipment and attachments such as Cranes, Bulldozers, Scrapers, Sheep-foot Rollers, etc. A small workshop is also at Hazaribagh and Mobile workshop unit is used in one of the large camps. See chart 1.

Staff

The present staff of the Circle in the regular establishment consists of one Superintending Engineer, one Executive Enginer and one Senior Mechanical Engineer of the equivalent rank of Executive Engineer, four Assistant Mechanical Engineers, and one Assistant Accounts Officer, two Assistant Civil Engineers. 62 Operators, 50 Mechanics, Fitters, Electricians, Blacksmiths, etc., and other clerical and accounts staff also form a part of the regular establishment. A Stores Organisation is also attached to this Circle, supervised by one Stores Officers and suitable numbers of Storekeepers and assistants both for Central and Field stores. In addition to above, suitable numbers of work-charged personnel are employed from time to time as per requirement of works.

The small worshop at Hazaribagh handles practically the entire major repairs of the equipment of the Circle under the direction of a Workshop Superintendent with a nucleus of mechanical staff.

Projects and Works executed

(*a*) *Reclamation of wasteland for rehabilitation*

Construction of main reservoirs created vast areas of submergence displacing a large number of people and it was obligatory to provide land for these people. Reclamation of wasteland in nearby areas was started for this purpose. The first Dam to come up was at Tilaiya and operation of reclamation of wasteland in that area started in 1949. It was originally proposed to reclaim very shallow slopes of wasteland. Problems such as non-availability of such suitable land with sufficient soil depths acceptable to displaced persons and not far from the submerged areas, land acquisition difficulties, options, etc., arose. Subsequently it was found that the land available for reclamation had 4 to 5% slopes compared to 2 to 3% originally estimated. Much bush and jungles had also to be cleared in the available area which could not be foreseen.

The terrain of the land also varied as the soil condition was extremely hard from November till the end of May, necessitating very frequent changing of cutting edges for dozers and scrapers. This was due to the high quartz composition in the eroded soils of the Chotanagpur plateau. During the monsson the

Waste land with Canary Hill in the background., Hazaribagh.

soil became too soft for work by machines and therefore, the machines could not be worked for the full sason as planned.

Grader at work at Deochanda.

Originally power scrapers were used to make fields. As these required larger turning radius and had capacity to transport materials to longer distances, it was planned to reclaim larger fields to make the operation economical; but the cultivators preferred smaller fields making the use of these machines impracticable. Slopes of the land also did not permit larger fields either and hence the power scrapers had to be used eesewhere.

Even the crawler tractor and scraper operation was found to be uneconomical as the extent of movement of soil from the higher to the lower slope was limited. In other words, the soil had to be cut from the higher side and pushed to the lower side to a distance of a maximum of about 50 feet. By cutting on the higher side and pushing downwards, the land was automatically levelled and bulldozers were found to be most efficient and most economical for this purpose. This system was followed successfully since then. Bunds were formed by repushing the levelled soil from the lower side of the slopes upwards to the higher side. This involved double handling by crawler tractors, but was justified by the use of lighter equipment for this purpose.

Reclamation in Konar areas started in July 1952. Here every gulley reclamation was carried out by dozing sides of gullies and filling up gaps. Considerable amount of jungles had also to be cleared before any dozing operation was possible. Ponds were also made above the gullies for irrigation purposes. Volume of earth moved per acre of reclamation in this area was much more than that moved in Tilaiya areas due to the existence of gullies.

Mechanical levelling of a ploughed field in Singrawan village (one of the four rehabilitation villages built by DVC).

Reclamation for rehabilitation of displaced persons in the submerged area of Maithon reservoir started in December 1952. The reclamation here was very similar to Tilaiya areas with equal slopes and soil. There was less bush and jungles to be cleared. Due to difficulties in option of land from villagers, reclamation in this area has been very erratic and continuity could not be maintained. This caused heavy expenditure by idle-time of men and equipment.

To give a rough idea of the amount of work involved

Reclaimed land with irrigation in Tilaiya Rehabilitation areas.

in each type of area, in Tilaiya 600 cubic yards of earth per acre had to be moved, and 500 acres of jungle had to be cleared in a total area of approximately 4500 acres reclaimed. Similarly, 1500 cubic yards per acre of earth had to be moved in Konar together with 516 acres of heavy jungle to be cleared. In Maithon, 700 cubic yards per acre of earth had to be moved. In all areas additional double handling of earth had to be done for forming bunds. The total earthwork involved was 45,00,000 cubic yards, in 6500 acres of land reclaimed.

(*b*) *Headwaters Control Dams*:

The Soil Conservation Department had as one of its main functions the control of erosion as well as prevention of silting of major reservoirs by soil conservation measures. This has a large contribution towards the extension of life of major Dams. These Headwaters Control Dams are meant for this purpose and also for supplying water to nearby towns and for irrigation, and we have so far carried out construction

Gonda Spillway

of 4 such Dams, two for purely irrigation and two for water supply for Hazaribagh and Ranchi towns as 'deposit works' for the Bihar Government. Charrwa Dam, built for water supply of Hazaribagh town, also irrigates one thousand acres of land. Total earthwork carried out by machines for these Dams amounts to roughly 11,00,000 cubic yards.

Ranchi Earth Dam under construction

(*c*) *Canal works for Barrage & Irrigation*

Early in 1953, this Circle started excavation of certain sections of Navigation and Irrigation Canals for the Barrage and Irrigation Department of DVC,

Panagarh Branch Canal excavation by 54-RB Draglines

on a priority basis. Power Scrapers and Dozers were used for the Navigation Canal as suitable Draglines were not available. Motor Graders were used for grading purposes. 2½ Cyds. Draglines were used on the Irrigation Canal. So far we have done 27,00,000 cubic yards of earthwork on these Canals.

Panagarh Canal—another view

(*d*) *Miscellaneous Works*

Over and above the works carried out, as noted above, this Circle had to do many other miscellaneous works. An earthen bund was constructed for the Cable Factory at Chittaranjan. The ground was swampy and great difficulties were faced. We had no bulldozers at that time, and tractors and scrapers had to be used as dozers, and the work was started during the monsoon season and completed in 3 months inspite of adverse conditions.

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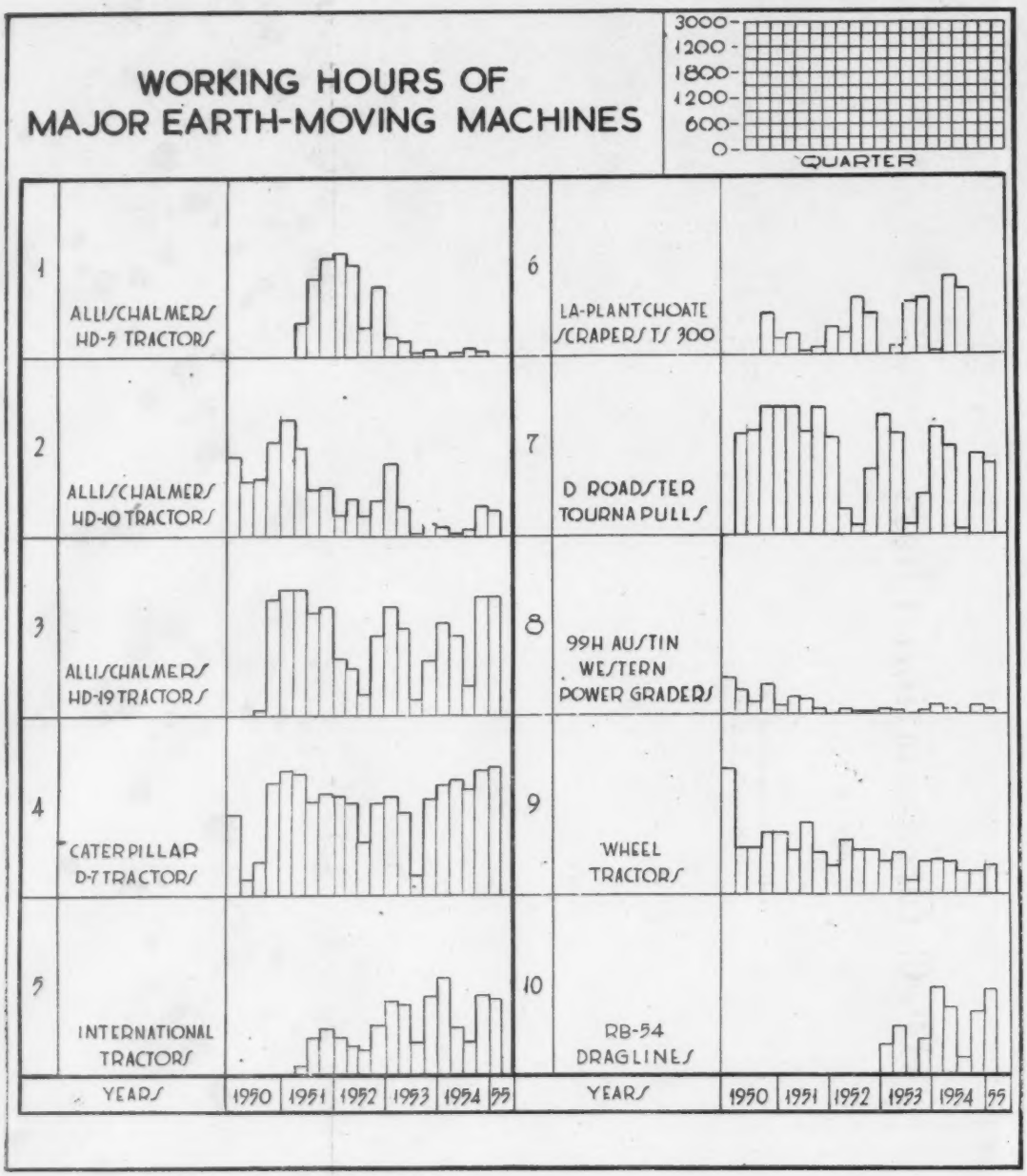

WORKING HOURS OF
MAJOR EARTH-MOVING MACHINES
3000-
1200-
1800-
1200-
600-
0-
QUARTER
1
ALLIS/CHALMERS/ HD-9 TRACTORS/
2
ALLIS/CHALMERS/ HD-10 TRACTORS/
3
ALLIS/CHALMERS/ HD-19 TRACTORS/
4
CATERPILLAR D-7 TRACTORS/
5
INTERNATIONAL TRACTORS/
6
LA-PLANTCHOATE /CRAPERS/ TS 300
7
D ROADSTER TOURNA PULLS/
8
99H AUSTIN WESTERN POWER GRADERS/
9
WHEEL TRACTORS/
10
RB-54 DRAGLINES/
YEARS/
1950
1951
1952
1953
1954
55
YEARS/
1950
1951
1952
1953
1954
55

MECHANISED EARTH-MOVING CIRCLE /C.D. DVC.

PLANT OPERATION CHART (TYPICAL)

ESTIMATE OF PLANT MOVEMENT _____

SECTION	PLANT ITEMS. ESTIMATED	ACTUAL	M/C No.	ITEM NO.	MONTH:	MONTH.	MONTH.	MONTH.
					WEEK ENDING DATES			
					1	2	3	4	5	6	7	8	9	10	11	12	13	14
JUNGLE CLEARANCE	HD-19 TRACTOR & DOZER			1														
STRIPPING OF FOUNDATION	HD 19 " " & PUSHER			2														
	TOURNAPULL			3														
	" " "			4														
	" " "			5														
	" " "			6														
	" " "			7														
CUT OFF TRENCH EXCAVATION	HD-19 TRACTOR & DOZER			8														
	TOURNA PULL			9														
	" " "			10														
	LAPLANT CHOATE			11														
FILLING IN CUT OFF - TRENCH	HD-19-TRACTOR & DOZER			12														
	TOURNA PULL			13														
	" " "			14														
	" " "			15														
MAIN DAM FILLING	HD-19 TRACTOR & DOZER			16														
	HD-19 TRACTOR & PUSHER			17														
	TOURNAPULL			18														
	" " "			19														
	" " "			20														
	" " "			21														
	" " "			22														
	LAPLANT CHOATE			23														
	TD-14 TRACTOR & ROLLER			24														
	WATER SPRAYER			25														
SLOPE DRESSING	HD-19 TRACTOR & DOZER			26														

MECHANISED EARTH-MOVING CIRCLE /C.D. DVC.

BOOK No. _ PAGE No. _

SUB-STATION: WEEKLY PLANT & PROGRESS REPORT (TYPICAL) W/E

No.	MACHINES AND ATTACHMENTS	No. OF MACHINE	HOURS ON DIFFERENT WORKS A	B	C	D	E	F	G	H	I	J	CHART OF HOURS 20 40 60 80 100
1													
2													
3													
4													
5													
6													
7													
8													
9													
10													
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													
		TOTAL											

PROGRESS REPORT

CLASSIFICATION	PREVIOUS TOTAL ACRES	PREVIOUS TOTAL C. YDS.	CURRENT PRG. ACRES	CURRENT PRG. C.YDS.	TOTAL TO DATE ACRES.	TOTAL TO DATE C.YDS.

LOCATION OF WORK — TOTAL

WORKS				
A		F		
B		G		
C		H		
D		I		
E		J		

REMARKS:

OFFICER-IN-CHARGE CAMP. DATE .. .... 19?

SURVEYOR

REMARKS:

A.E. (CIVIL)

MACHINE :- ... ...
NO. OF MACHINE :- ... ...
TYPE & No. OF ENGINE :- ...
ATTACHMENT & No :- ...
No. OF P.C.U. :- ... ...

MECHANISED EARTH-MOVING CIRCLE SCD. DVC.

LOG RETURN

BOOK No. :- ...
PAGE No :- ... ...
DATE/FE :- ... ...
SUB DIVISION :- ... ...
UP TO DATE HOURS (W&J) :- ...

SHIFT	OPERATOR	RUNNING TIME (HOURS) WORK TYPE	W	J	IDLE TIME S	IDLE TIME W/D	FUEL (GAL) DIESEL	FUEL (GAL) PENERINE	FUEL (GAL) PETROL	LUBRICANTS (GALLONS) HYP-90	HIP-140	DEU-A	DEU-O	AUTO	CRK-30	CRK-40	HLO-30	FLUSH	GREASES (LBS)						CAUSE OF STOPPAGE	CAUSE OF BREAK-DOWN	REPAIR DONE	SPARES USED	DETAILS OF LUBRICATION
		TOTAL																											

GENERAL REMARKS ... ...

FORE MAN STORE KEEPER OFFICER IN-CHARGE

MECHANISED EARTH-MOVING CIRCLE SCD. DVC.

FORM NO 5

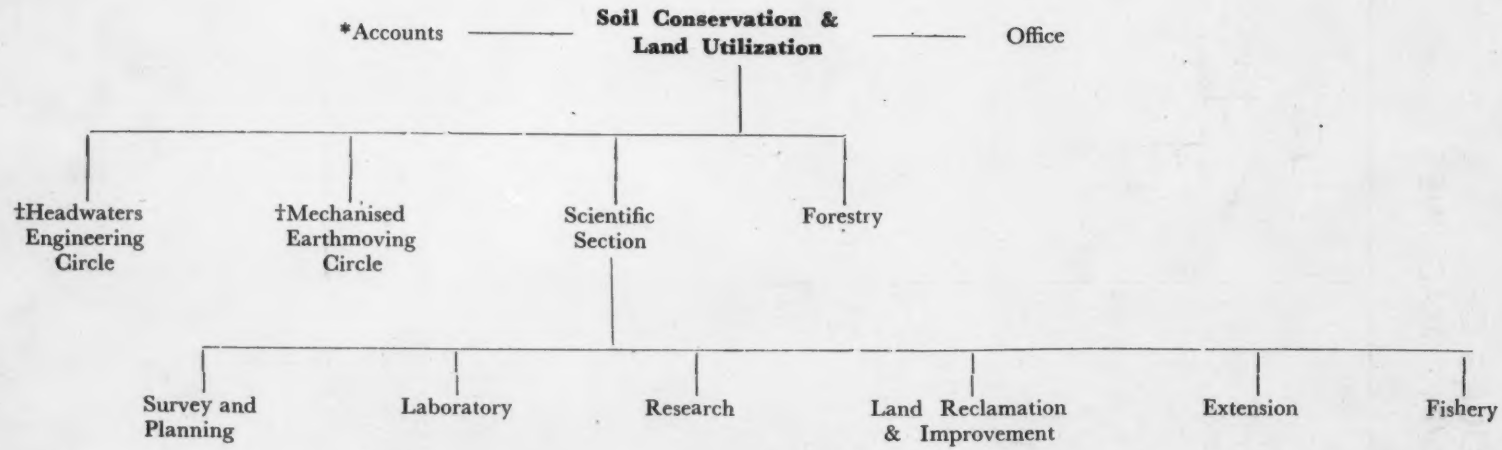
COST SHEET FOR (CAMP) ... ... FOR THE MONTH OF ... ...
Number of machine
Total hours

-	AMOUNT			TOTAL		
DIRECT CHARGES (Materials as per plant returns or summary)						
(a) Fuel						
(b) Lubricants (For normal maintenance)						
(c) Spares						
LABOUR (as per esst. analysis sheet)						
INDIRECT CHARGES						
(a) Depreciation of machine						
(b) Proforma maintenance @ 150 % of depreciation						
Total cost for the month Rs.						

Unit cost per hour Rs ... ...
Unit rate of Overheads Rs. ... ...
Overall unit rate per hour of machine Rs ... ...

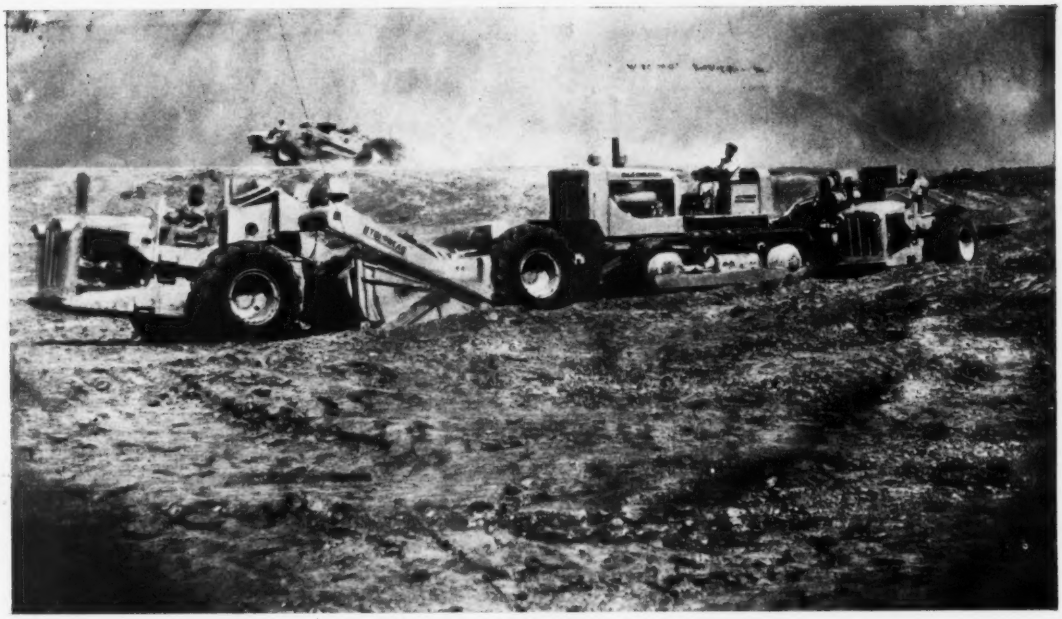
DVC Organisation Chart

March 1955



*Amalgamated with A/C office of Rehabilitation & Development Department.

‡Thease two circles are controlled by the Chief Engineer.



Scrapers working at Deochanda.

The D.V.C. Electricity Department needed two bases for their Sub-Stations at Sindri and in Calcutta on priority basis, as manual labour was more expensive and time-taking. Levelling and building of these bases were done economically and well ahead of schedule by machines of this Circle.

The Bokaro Thermal Power Station needed urgent excavation of Intake and Discharge Channels for cooling purposes of the Station. For this purpse one earthen bund had to be constructed adjacent to the Barrage, and a rocky and shaly area had to be excavated for Channels. Considerable blasting had to be done and shovels, dozers, scrapers and dumpers were used. Wear and tear to the equipment was considerable due to the heavy nature of this work. The work was completed within the specified time of about six months.

To facilitate the contractors obtaining sufficient borrow area material for the construction of Konar Dam, speedy clearance of jungles, derooting and stripping of top soil on borrow areas was necessary involving a total of about 4,78,000 cubic yards of earthwork, and clearance of jungles in an area of 314 acres. See Charts 2 & 3.

The total volume of earth moved and jungle cleared for Miscellaneous Works are 10,00,000 cubic yards and 314 acres respectively. See oharts 2 & 3.

Costing

It was necessary to do detailed technical planning for operation and for this purpose commercial costing was found very essential. Various forms had to be designed to obtain datas for compilation and computation of cost from the Field, from time to time, and procedure had to be drafted with details of progress charts, machine output, consumption of petrol, oil, lubricants and greases, details of hours of machines engaged on different subsidiary works, value of spares quantities used on repair and maintenance, etc. All these had to be obtained weekly and the cost accounts procedure was planned as shown in charts 4 & 5.

(*a*) *Fixed Charges*

This covers Depreciation, Maintenance, Interest, Insurance and Percentage of expenditure incurred by Head of the Department, Head of the Circle, and the office staff, General Overheads of the Corporation inclusive of Audit, etc. Life of machines taken varied from 8000 hours to 12000 hours for tractors, power scrapers and crawler scrapers, and 10000 to 20000 hours for draglines and shovels, based on their capacities.

Experience of users of large scale machinery are varied with regard to the cost of maintenance ranging from 60 to 200% of Depreciation charges. This also depends mainly on conditions of working, efficiency of operational personnel, satisfactory maintenance, etc. For all estimates, 150% of Depreciation has been taken as proforma Maintenance. This rate may be exceeded as the machines grow older. Lubricants, Greases and other consumable stores also form a part of Maintenance.

(*b*) *Direct Charges*

All these pertain to actual expenditure incurred by men and machines,—Officers' salary, allowances of field officers, etc. This excludes supervisory staff

[*Continued on page* 78

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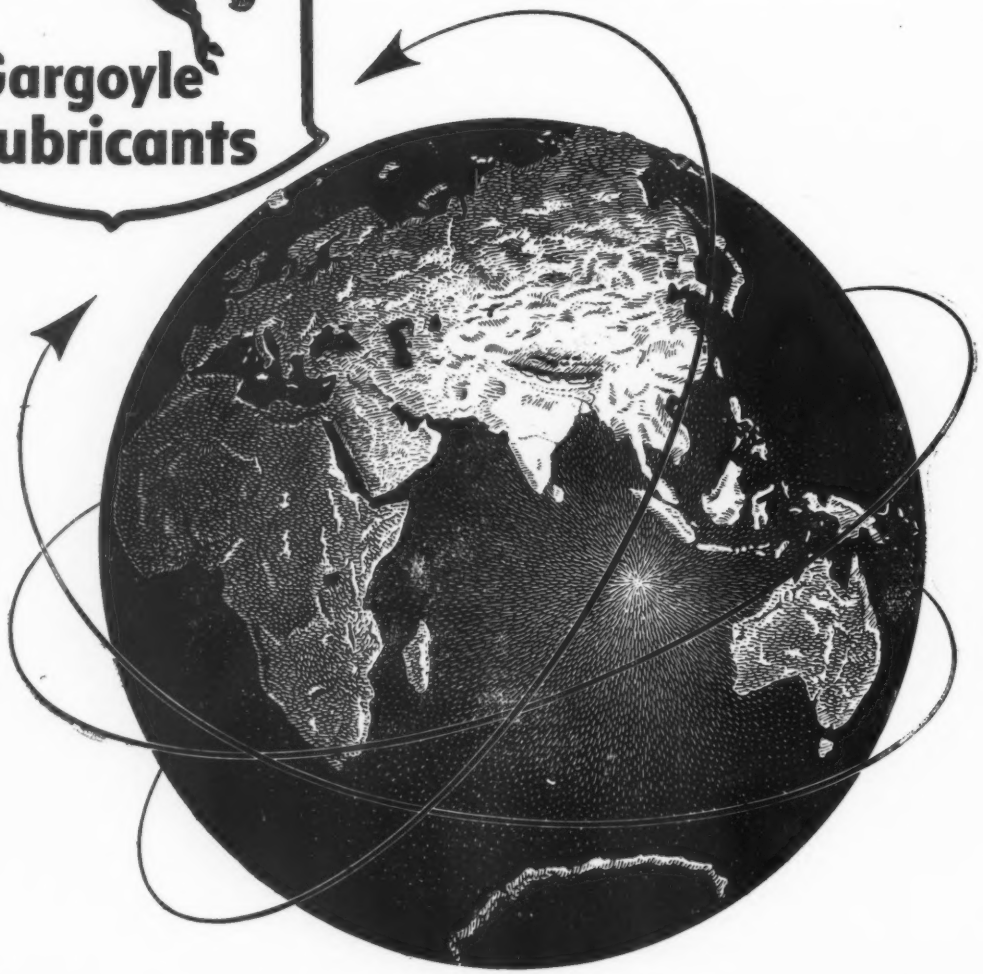
Gargoyle Lubricants



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V. 1791

Industrial Development in River Valley Projects

J. D. LONG

Mr. Long is a welknown expert belonging to the Armour Research Foundation of U.S.A. and has earned great credit and reputation in whichever part of the world he has worked. He has been in India for about two years as DVC consultant for Industrial Development and has spent most of his time in the area studying the life and needs of the community and the potentiality of their development. The following contribution is based on his deep and sympathetic study of the problem and the approach and pattern of development he has suggested with particular reference to the Damodar Valley deserves the attention of not only the D.V. Corporation but also of all River Valley Authorities in India as also the Central and States governments. Our Directorate of Industries in the States are yet in their infancy. We have just begun to stress on small and cottage industrial development on a national scale. It is, therefore, opportune that Mr. Long's mature judgement on these matters is available to us through this able contribution.

AUTHOR

Economic development is one of the major objectives of river valley development projects. In the initial concern with the design and construction of dams and power house, however, the industrialization phase of the development program is too fequently put aside for later consideration. There is likely to be expectation that industries will grow up spontaneously, once electric power and water are available.

It is true that power and water are among the major considerations for many industries. Some will locate voluntarily in a region where these resources exist. But varied types of industries are required to obtain a balanced industrial economy for a region, one which will most thoroughly capitalize on all of the local resources and most fully meet the requirements of the local inhabitants and of the nation. There are always opportunities to improve the traditional industries, to introduce new ones, and to stimulate a more rapid rate of development.

A river valley development project, being concerned with a well-defined geographic unit with many common characteristics,, is a logical and effective medium for conducting an industrial development activity. Being essentially an action agency responsible for constructive results, a Regional Development Authority is likely to be more realistic and productive, and less handicapped by bureaucratic procedures, than other governmental organizations. The primary objective of any development project is the optimum utilization of all of the available resources. Providing new power and water resources is only an initial step toward the agricultural and industrial developments which are the actual wealth-producing activities.

General considerations

Man has three basic requirements: food, clothing and shelter. The present stage of civilization has added many qualifications as to acceptable dietory standards, adequate clothing and comfortable, healthful housing. In addition, secondary requirements of education, communication, transportation, medical service, recreation and cultural growth have become essentials. The degree to which these human requirements and needs are provided by a population is termed its "standard of living". In the fundamental analysis, agricultural and industrial development programs are simply action programs to provide the goods and services which will improve the standard of living of a people. Merely providing employment is but a complementary aspect to this basic concept.

It is obvious that agricultural and industrial development programs must be integrated. Industry provides many of the goods esential to agricultural development such as improved production tools, commercial manures, chemical insecticides and herbicides, and similar products. Agricultural products, on the other hand, frequency become the raw materials for industry, among them cotton and other fibres, edible and industrial oils, cellulose for paper and synthetic fibre products, etc. Industrial processing, refrigeraton and

Village markets are an excellent place to study the industrial products used by the local populace.

J. Dewey Long *belongs to the Armour Research Foundation, Chicago and was Industrial Development Consultant to the DVC.*

Traditional methods of fishing can be developed into a commercial fishing industry if adequate facilities, including cold storage, are produced.

transportation services can make possible the production of agricultural commodities which are new to a region or which prevent agricultural wastes, and so contribute greatly to the production of new wealth.

Full utilization of the minerals, forestry and fishery resources of the region must also be incorporated into the industrialization program. Even more important are the encouragement and development of the traditional skills and abilities of the people toward increased productivity.

It is essential that these activities be undertaken with the full participation and cooperation of the local inhabitants. They can be guided and introduced to new concepts, but first priority should be given to needs which they themselves recognize as desirable.

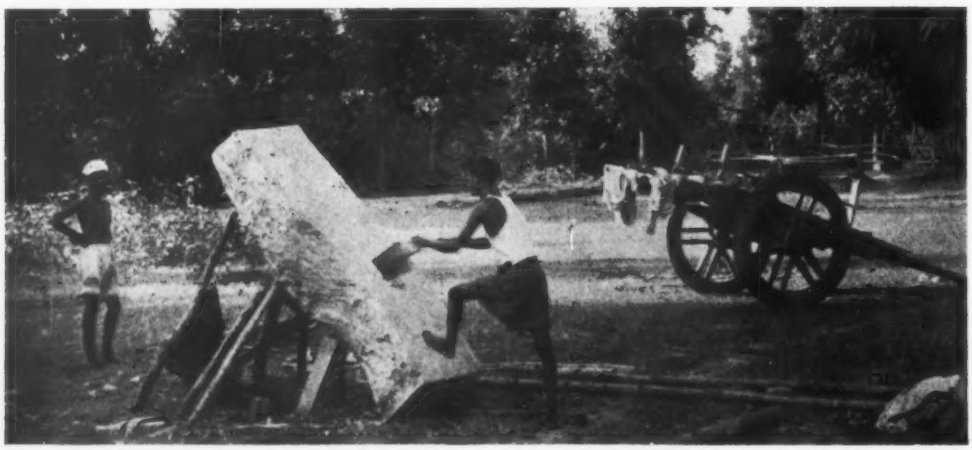
Exploratory and demonstration industries can, and should, be introduced and operated by the sponsoring agency. Personal initiative and self-reliance must be encouraged, howeveer, if the people are to develop into stable, productive citizens of a democratic state. Automatically, therefore, private enterprise must bear the main burden of the regional development. There are many inducements and many ways in which leadership can be provided to private industry and this leadership is the true function of government in such a development program.

The Development Wing

Industrial development is a complex and technical activity. It must be based on adequate knowledge of the region. It must have a social philosophy and a concrete program of constructive work. There must be an appreciation of the fact that collection of data, and planning, are necessary and continuing functions, but early implementation of the more difficult practical activities is essential to actual development progress.

A primary requirement is the establishment of a competent Development Wing at the highest adminstrative level within the sponsoring agency. It should be initiated as early as possible in the development program in order that it may work concurrently with the physical construction of the dams and other facilities. It should embrace both agricultural and industrial development activities, in order that the two may be properly integrated. Qualified men must be appointed to the staff and given opportunities for contracts with other specialists and projects in the industrial development field. A reasonable budget must be sanctioned, and funds made readily available to speed the progress of the program.

It is especially important to appreciate that competent men always respond to a constructive challenge and to a definite opportunity for practical work. They will be anxious to assume responsibilitis and to produce results which prove their abilities. The calibre of the industrial development officers is the maor index of the probable success of the program.



Forest conservation requires both wise forestry management and full wood products utilisation. The latter depends upon modern industries, such as sawmills, dry kilns, timber fabrication plants, wood preservative treatment plants, and carpenter shops.

The traditional potter's wheel (above) used here for making country roofing tiles. Modern equipment, such as the electrically vibrated hollow concrete block machine (below) enables a worker to produce more and at lower cost.

The Program

A realistic program can be developed only from a knowledge of the particular region to be served: its industrial history and traditions, its resources, both human and materialistic, and its current level of development. A well-balanced program incorporates many types of activities which may be grouped in three main sections: General, Non-profit and Sponsored.

A. General Activities

There are several activities which should be included in the program which require moderate expenditure without the prospect of a direct financial return.

1. *Regional Planning*

Basic information and data of a region can only be secured from actual field studies and surveys. Some of this information may already be collected in census data, geological surveys and similar reports. Additional and current information is usually required, however, to cover satisfactorily the various economic, social, cultural and physical characteristics of the area.

A technological audit of existing industries is essential to determine their type and the level of productivity. First-hand studies of the traditional village industries, especially, will give valuable data on the techniques and production equipment which are used. Production cost studies of selected units, and data on financing and marketing problems, will assist in planning the most practical methods for betterment of the economic position. Studies of local village markets give an excellent picture of the industrial products currently essential to the populace. Establishing a museum of typical industrial products provides a valuable reference. This technological audit is essential, even though the other phases of the Regional Planning Study may be postponed.

These other phases which constitute the main body of the Regional Planning Study will encompass the physical and climatic characteristics of the region, the distribution of population and employment characteristics of population centres, land use (both present and potential), material resources (agricultural, geological, forest and fisheries), utility resources (power, water, transportation and communication), industrial site development potentials, housing and labour colony planning, education, public health, religious observance, places for public assembly opportunities for cultural improvement, entertainment and recreation, social factors and pertinent legislation.

The initiation of other industrial development activities should not be delayed pending completion of the Regional Planning Study. There are many activities which can be undertaken immediately for the economic betterment of the region.

2. *Industrial Site Development*

Establishment of an industry in an under-developed region is always accompanied by many special problems and obstacles. Among them are the selection of a suitable site and the actual acquisition of the necessary land. It is important, therefore, that the industrial site development activity should progress beyond the regional planning study phase and should provide concrete assistance to prospective industrialists in the location and acquisition of suitable sites.

It will be wise in the early development stage to select suitable industrial areas and to provide them with roads, communications, power and water as inducements. Permanent construction camps required for major dams and other works may be suitable for industrial sites later, if pertinent facilities are provided and if provision is made for sale or long-term rental to industries when the construction is completed. This possibility is discussed in greater detail under the heading of Industrial Finance. Encouragement and assistance can also be given to the authorities of established towns in the region to improve the facilities and amenities of their population centers in order to attract industries and to bring their communities to the standards of the newer ones being developed in the region.

Aerial photographs and maps of the more desirable industrial areas are excellent mediums for study and

for the preliminary selection of sites for individual industries. Data should be compiled on the characteristics and facilities of each proposed industrial area, to be used in conjunction with the photographs and maps, both in planning and in discussions with prospective industrialists.

3. *Industrial Research.*

Research is an essential component of modern industry. It is very desirable that industrial units or groups be encouraged to conduct research pertinent to their individual requirements, perhaps with some government assistance and leadership. Smal-scale and cottage industries are seldom sufficiently far-sighted or financially able to initiate research programs; government, therefore, has a responsibility for conducting a realistic and aggressive experimental program for such industries. This should encompass studies of raw materials, product design, producton techniques, equipment and costs, marketing and financing, both for existing industries and for new types of production units which may be introduced to the region.

Geological, forestry and fisheries surveys of the commercial quality and quantity of local raw material resources should be included in the technological audit. Workshop facilities will be required by the industrial development engineers to permit characteristics studies of different types of production equipment and to develop new production machines and techniques. Some sponsored research should be places with suitable universities or research laboratories to develop new chemical, mechanical or electrical techniques, equipment or products which can form the basis of new industrial developments. These research results may be expected to feed into the actual experimental or pilot plant industries discussed under the heading of Sponsored Industries.

4. *Education and Promotion*

There are many types of desirable activities which may be included under this heading. Industrial specialists or extension workers may be employed to work with the cottage and small industrialists to encourage them to adopt improved practices and to help keep them informed on the raw material and finished products markets. Lists may be prepared of suitable industrial opportunities in the region, preferably with brief descriptions and data for each industry, to distribute to prospective investors. Pubished data sheets on the characteristics and facilities of each industrial site are also of great value in this connection. Record sheets should be prepared for taking pertinent data on each prospective industrialist, his industrial interest, potential and requirements. Carefully prepared publication and advertisements of the region and its industrial opportunities should be used to attract prospects. Photographs and motion picture of existing industries and of new improvements and developments can be used to excellent advantage.

It may be desirable in some instances to pay specialists' consulting fees for advice on specialized industrial problems. The impartial viewpoint of a qualified specialist from outside the region can often be of major benefit in considering difficult problems or in ascertaining the scope and priority of activities.

Attention should be directed also to attracting the favourable consideration of consumers to the products of the region. Publications, advertisements, exhibits and motion pictures should be used to advise the public of the industrialization program and of the quality standards for the products being manufactured. Public exhibitions of typical products are very desirable Attractive and accurate trade and grade markings should be developed and used on those products which meet specific minimum quality standards.

B. Non-Profit Enterprises

Some of the activities which are essential to the economic development of the region and which should be initiated early in the industrial development program, bring a financial income but normal should not be expected to make a profit. Under good management they may beome self-supporting. They are sufficiently important that even if they operate at a small financial loss, the sponsoring agency should subsidize them.

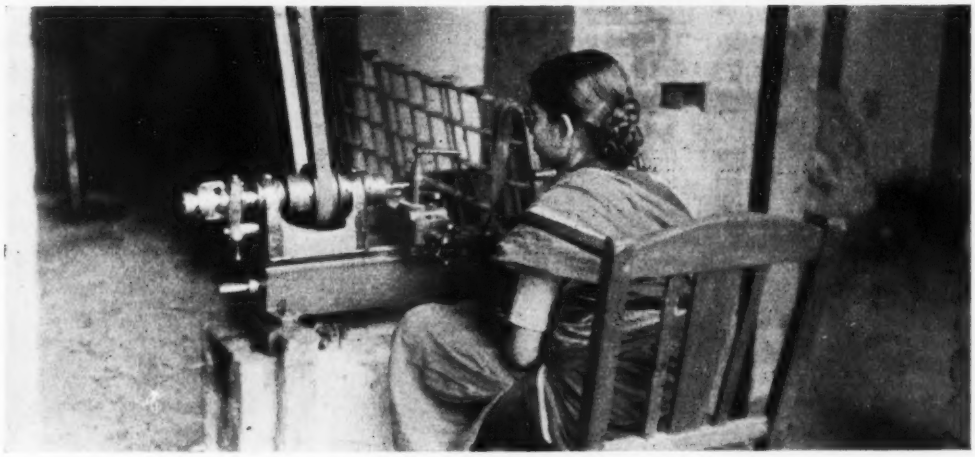
1. *Marketing Service*

A properly-organized marketing service for buying and re-selling the villager's wares is perhaps the most productive activity which can be initiated to improve the economic position of existing cottage and small industries and to encourage the formation of new units. Receiving orders for his products and being paid immediately upon delivery are powerful inducements to the worker for greater production. Procuring raw materials of proper specification through the marketing service will frequently relieve the worker of one of his major problems. Working on improved or new designs of products will enlarge his abilities. The confidence inspired by such transactions will make it possible for the development officers to introduce to the workers new designs, materials, techniques and production equipment.

It is of importance that the Marketing Service should not take the full output of any individual producer, thus divorcing him from his other maketing outlets. Rather, if not more than 25 percent of his wares are purchased to be resold in markets which are not competitive with his remaining production, the desired results will be attained.

The products purchased by the Service should only be those of such designs and qualities as can be readily marketed in other parts of the region or in distant urban centers. The employment of qualified designers or the cooperation of an Industrial Design Institute should be an integral part of this activity,.in order to insure ready marketabi.ty and to be of greatest service to the consumers, and hence to the producers.

The manual wood lathe (above) does not permit work of the same quality as the machine lathe (below)



2. *Industrial Finance.*

Finance and credit are among the major problems of small producers. Frequently they are in debt and can operate only with the favour of money-lenders.

In initiating the industrial development program, every effort should be made to secure the full cooperation of local banks and of State and Government sources of commercial credit. It is probable, however, that all production needs cannot be met from these sources.

An industrial finance plan, operated in conjunction with a marketing service, can help provide raw materials and can place improved production equipment in selected industrial units on a hire-purchase plan. Depending upon local needs and administrative regulations, this financing may be used to purchase land and erect buildings for approved private industrial enterprises. Stock shares may be purchased in the new enterprises. The fund may also be used to purchase tracts of land and to improve them with roads, water and electric supply into industrial areas to be sold piecemeal to small industries. It is obvious that the industrial finance must be conducted on sound economic principles and under the guidance of reliable technical men who can judge the financial merit of each loan or investment proposal.

3. *Portable Diesel Generating Sets*

It usually requires several years for a net-work of secondary electric transmission lines to fully cover a region. Unless this project is heavily subsidized by government, the construction and maintenance costs of a power net-work cannot be met from electricity sales revenues initially; time is required for sufficient productive uses of electricity to be built up to justify the necessary expenditure. Even if a high-voltage line passes near a village, electricity cannot be made available to the inhabitants until an expensive transformer is installed.

For introducing electricity into a region, a number of portable diesel engine generating sets of 10 to 50 KVA can be used to advantage. Placing a small set in a village which has been carefully selected for its potential use of power in industrial or agricultural production, will require the construction of one or two miles of transmission line, installation of house and industrial

wiring and a plant operating crew. Rates charged for electric service should be similar to those charged for transmission line power; initially, such installations cannot be expected to pay their costs and so must be subsidized. The psychological stimulus given to the region, the experience gained by both small industrialists and the development officers in the productive use of electric power, and the new agricultural and industrial wealth which can be created justify a reasonable subsidy

When the power load built up by the portable set has reached a satisfactory level and transmission lines can be constructed to the village, the diesel generator can be moved to another village and the process repeated.

4. *Housing*

Housing is an ever present need. With an increasing population desiring improved housing to meet higher living standards, technical guidance and material assistance are necessary to cope with the housing requirements of a development region. Numerous opportunities are presented also for the establishment of new industries to manufacture building materials and to construct new dwellings.

Demonstration houses illustrating modern designs suitable to the region and to the local economy should be constructed in several population centres in the region. Improved techniques for using local construction materials and the use of new complementary materials and components can be graphically shown in this way. These dwellings can be used by development personnel or sold to private individuals after the demonstration period.

Group housing programs of suitable nature can be developed for construction employees, resettlement villages, individual industrial enterprises and industrial site developments. In considering group housing, it should be remembered that the stability and security of home ownership are desired by most families. Oil companies and other industrial enterprises have found it advantageous in recent years to give guidance and assistance to employee groups who assume responsibility for the construction and maintenance of employee housing colonies, rather than to erect "company colonies". Mutual agreement on suitable standards of construction and maintenance, and provision for individual ownership are essential features of such programs.

There are many industrial opportunities associated with the housing program. These include the manufacture of brick, hollow concrete block, floor and roof tile, precast concrete roofing slabs, and both organic and inorganic insulation materials; the processing of oils and paints; the sawing, kiln drying and preservative treatment of lumber; the fabrication of roof trusses and door and window frames; the electric wiring of houses; and the manufacture of furniture, household utensils, pumps for domestic water supply, and similar items.

C. Sponsored Industries

There are several reasons for including the financing and operation of a few actual industrial enterprises in the industrial development program. They will prove to the public that a determined development program is in progres and will encourage prospective industrialists; they will open up new types of industrial activities and serve as actual wealth-creating enterprises; they will set a standard for other industries in the region in production and marketing techniques and in labour relations; they will provide a proving ground for the new industrial enonomy, and will enable the development officers to conduct the other phase of their program with the assurance gained from actual management experience.

Types of Industries

Careful consideration must be given to the selection of industries which are needed in the region. In general, this will mean that they will be related to the agricultural, mining, forestry and fisheries activities, and to complementary needs such as housing, transportation, electricity, water supply and other consumer requirements. Opportunities will be found to create some industries ancillary to other production units.

There is great scope in the handloom industry for the development and introduction of simple manual or powered preparatory equipment and improved handlooms.

None of the sponsored industries should be directly competitive with private enterprises which are already established.

The new industry possiblilities suitable for the sponsorship of the development agency can be considered in two categories; (1) those which can be organized and operated as commercial production units, and 2) those which will require an initial period of exploratory development before they can become fully-productive enterprises.

It is essential that the enterprises in the first category be operated on a comercial basis, with competent management given adequate responsibility and operating funds, and held to the necessity of making each enterprise a profitable operation. These are demonstration enterprises, and should be freely opened to inspection by prospective industrialists. When they have proven to be stable profitable enterprises they should be sold and the capital so recovered used by the development agency in starting new units.

Small sanitary structures can be built for food processing, such as oil expelling, rice hulling, floor milling and gur making.

Industries of the second category will be exploratory or pilotplant enterprises, which may require two to five years before they can be safely formed into commercial ventures. These constitute one phase of the research which must be undertaken in order to provide industrial leadership and to fully meet the objective of developing all of the potential resources of the region.

A balanced development program must include examples of both categories of sponsored industries.

Examples of Selected Industries

It may of interest to mention here the small industries which have been given consideration in the industrial development program of the Damodar Valley Corporation.

Scheme No.

1. Central Finishing Workshop for Hand-forged Items.
2. Cold Storage Industry.
3. Ceramic Products Industry.
4. Aloe Fibre Production, Processing and Utilization.
5. Improved Woodworking shop.
6. Lock Manufacture.
7. Preservative Treatment of Wood Products.
8. Irrigation Pumping Service.
9. Cotton Spinning Industry.
10. Improved Oil Ghani.
11. Industrial Minerals Processing.
12. Demonstration-cum-Production Centre for Handloom Textile Industry.

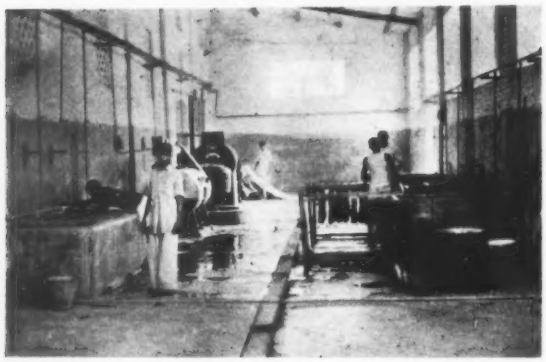
The titles alone donot adequately convey a description of the actual products or scope of activity which have been considered as desirable for this region. It will be noted, however, that the list is intentionally diversified as to types of industries and that both commercial and development schemes have been included.

Industrial Cooperatives

In the organization and management of the demonstration commercial industries, consideration should be given to the formation of worker cooperatives to which the enterprise may eventually be sold. It must be understood that cooperatives are not "miracle performing" organizations; rather, they are subject to all of the hazards of private enterprise, with some additional ones peculiar to cooperative operation. They cannot be formed overnight and be expected to prosper; allowed to grow gradually under competent management they have a much better chance of success. If the workers of a commercial enterprise are given the opportunity to form a cooperative, and voluntarily chose to do so, they can work toward the ownership of the plant in which they are employed. The profits of the enterprise can be divided annually into three funds, for example: 25% of the profits might be distributed as an earned bonus, 25% may be required for plant maintenance and improvement, and 50% used to amortize the capital investment. Each year, cooperative stock shares equal to the capital amortization can be distributed among the workers and plant management staff in proportion to their regular earnings. When the investment has been fully amortized, the cooperative would own the establishment and business and continue to operate it with fully-trained personnel. The experience of working together over a period of years to earn their enterprise should enable the cooperative members to continue it as a stable and profitable venture.

Preparation of Schemes

The drafting of each scheme for a sponsored industry requires competent technical and business ability and judgement. The first requirement is reasonable assurance that the proposed products can be marketed in the quantities and at the conservative sales prices which have been estimated. The second is that products of desirable quality can be produced and distributed to market outlets at the calculated costs. An acceptable scheme should include information and data such as that noted in the following outline:



Central workshops, such as this yarn dyeing and cloth calendaring plant, can greatly facilitate the production of cottage workers within a twenty-five mile radius.

I. General Considerations

A. Product to be produced.
   1. Contribution to regional or national economy.
   2. Competitive market situation.
   3. Current imports & possibilites for export.

B. Specific objectives of scheme.
   1. Type, quantity & quality of products.
   2. Proposed marketing arrangements.

C. Proposed location of production unit.

D. Summary of facilities available and of those to be provided.

E. Labour Requirements.
   1. Availability of skilled & manual labor.
   2. Necessary vocational or apprentice training.
   3. Special wage incentives.
   4. Labor housing and other amenities to be provided

F. Raw material requirements & availability.

G. Summary of required finance estimates.
   1. Capital investment for land, building & equipment.
   2. Annual operating costs.
   3. Anticipated annual income.
   4. Capital investment per employee & estimate of number of workers indirectly benefited.
   5. Annual Value added by manufacturing.
   6. Estimated profits.

II. Datailed Data

A. Brief description of operating routine by processing stages.

B. Specification of plant requirements.
   1. Land type and area. Any special site considerations.
   2. Building specifications and sketch plans of equipment layout.
   3. Estimates of land and construction costs.

C. Specification of equipment.
   1. Size, type and productive capacity of each item.
   2. Cost estimate of each item.
   3. Estimated installation costs.

D. Specification of raw materials and supplies.
   1. Physical and chemical specifications.
   2. Estimated quantity requirements.
   3. Estimated costs, including transportation.

E. Specification of employees.
   1. Administration and supervision, with salary estimates of each.
   2. Manual workers, with wage estimates of each.
   3. Productive output anticipated for workmen at each major stage of production.

F. Marketing.
   1. System and outlets proposed.
   2. Employees required.
   3. Estimated cost.

It is obvious that the drafting of an acceptable scheme is not a simple procedure. Rather, it requires dilligent and honest effort, and high degree of technical competence. Preliminary drafts of each scheme should be placed before competent specialists and industrialists for constructive criticism. Only after thorough consideration and any necessary revisions should the scheme be presented for approval and allocation made of the funds necessary for its implementation.

Conclusion

Industrial development is a normal complement of river valley and other regional development programs. Planning and active promotion are required for a well-balanced development and the most rapid rate of improvement. It is complex, with opportunity for many types of activities which can be selected only after a study and evaluation of the individual needs of each region. It requires a highly competent development organization which is given adequate responsibility and support.

For a balanced economy, consideration and encouragement must be given to the entire range of cottage, small, intermediate and large basic industries. The importance of private enterprise in an expanding economy must be appreciated. Initial efforts may be concerned primarily with improving the economic position of existing and traditional industries, but research must be introduced to develop new types of production and to capitalise on all opportunities for creating new wealth.

Finally, it must be realised that economic changes always introduce new problems. Industrialization is not an un-mixed blessing; adequate consideration must be incorporated in the development program to anticipate stresses which may be developed and to avoid undesirable effects. Temporary labour dislocation can be minimised and workers from obsolete crafts absorbed in the many new jobs created in an expanding industrial economy.

The ultimate success of the industrial development program can be attained by working closely with the inhabitants of the region, developing industries to supply their immediate needs and gradually educating them to a higher standard of living.

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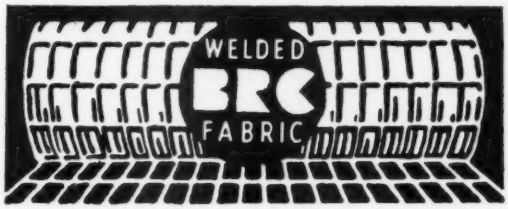

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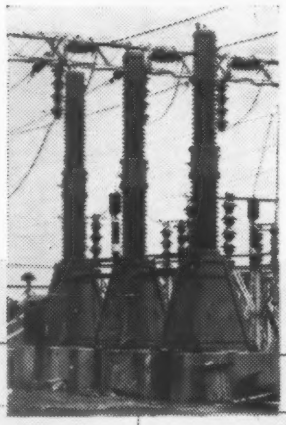

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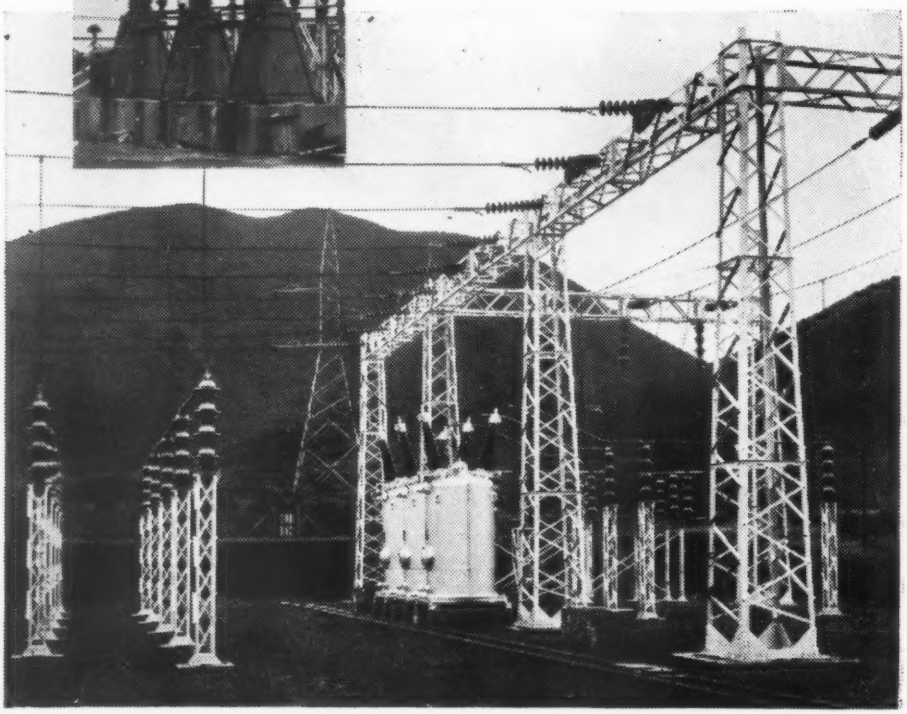

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Communication Facilities for Large Power Transmission Systems: Use of Unenergised Power Conductors as Telephone Circuits

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An efficient and reliable means of communication is a prime necessity for all large electrical power transmission systems for ensuring the desired standard of operation and maintenance of the transmission circuits, specially those operating over a wide area with inter-connected power stations and substations located at relatively large distances from each other. The communication facility to be provided in such cases must enable any station of the electric grid system to communicate with any other station at any time, so that messages relating to routine operational data as well as switching instructions can be exchanged freely both during normal operating conditions and during periods of emergency caused by generating station or line outages. It is therefore needless to emphasize that an exclusive communication circuit should be available to the power system operation engineers for 24 hours a day which should be dependable and free from frequent breakdowns. The need of communication facilities is also keenly felt during constructional stage of a Power Transmission Project.

The usual modes of communication are the following:—

(*a*) Power Line Carrier Communication,
(*b*) Wireless Communication,
(*c*) Telephone Communication.

The Power Line Carrier system which utilises the high voltage power conductors for carrying high frequency carrier currents is undoubtedly a very satisfactory means of communication, being particularly suited to a grid system operating over a wide area with a number of substations connected by high voltage transmission lines usually carried over strongly built towers. The system is, however, rather expensive and its adoption is economically justifiable when one or more of such other facilities like power line protection, telemetering, supervisory or remote control are employed in addition to telephone communication. Apart from the advantage that these additional facilities can be incorporated in this system, it provides a very satisfactory mode of communication, the signal-to-noise ratio being high and almost independent of external conditions. Moreover, the security of this system against physical hazards is much greater than that of an overhead telephone circuit. However, adoption of power line carrier current communication can not be economically justified for small power systems.

The wireless communication provided for power systems is usually in the VHF (very high frequency) range. Clear line of sight between transmitting and receiving stations being an essential condition for establishing satisfactory VHF wireless communication this is subject to limited transmission distance determined by the nature of the intervening terrain. Under optimum conditions, this system provides a fairly satisfactory communication channel, comparatively free from prolonged breakdowns due to seasonal weather conditions. A proper allocation of frequency however has to be obtained from the local communications authorities before planning the system. The need of a series of careful field investigation to determine the most suitable location of transmitting and receiving aerial masts cannot be over emphasised. A remarkable advantage of the VHF system lies in employment of mobile VHF stations for communication with fixed stations or between themselves to ensure speedy coordination of line construction work as well as routine maintenance or emergency inspection of faulty transmission circuits.

Before passing on to the subject of telephone communication, it may be worthwhile to make a brief reference to teleprinter service. Although more expensive than ordinary telephone system, this is a reliable means of communication if efficiently maintained and has a distinct advantage that messages or instructions communicated are recorded. But if this is to be of any use to a power organisation, they must have an exclusive right on it.

The overhead telephone system is by far the most

common place and in general, the most economical means of communication. But the exclusive use essentially required by the power systems often makes the cost prohibitive. When communicating centres e.g. power stations or substations are situated in out of the way places, the P & T public telephone facilities are extended on request by installing branch circuits reaching upto such remote locations. But the actual quality of service in such cases suffers from the following disadvantages:

(*i*) The prompt availability of communication channel under emergency conditions is determined by the through traffic on the trunk line.
(*ii*) The maintenance of the branch cricuits can seldom be of the same standard as the regular trunk line catering to the needs of the public.

In situations like this, installation of departmental telephone system to be exclusively operated and maintained by the power organisation appears a satisfactory solution.

The departmental telephone lines may be erected either on separate poles or on transmission line supports. While installing communication lines in the vicinity of high voltage lines, remedial measures must be taken wherever necessary to avoid excessive voltages on the telephone circuit due to inductive interference.

Telephone lines run below power conductors have the following advantages over lines on separate poles:

(*a*) Less cost
(*b*) Higher reliability as supports are more robust and can withstand heavier storms.
(*c*) Speedier installation.

Unfortunately, the former suffers from a serious disadvantage due to severe inductive interference from the power circuits run above, which affects the quality of communication and endangers safety of the operating personnel and telephone terminal apparatus due to high induced voltages. Hence, remedial measures are necessary to eliminate hazards and to improve the quality of communication when such installations are resorted to.

A very interesting and special case arises when unenergised power conductors are utilised as telephone conductors for establishing communication on a temporary basis. Often during initial stages of development of poweer system when essential operation of certain sections of transmission lines and urgent construction of certain others are to be undertaken, unenergised power conductors are pressed into service as temporary telephone lines.

Let us consider a case where it becomes necessary to employ conductors of an unenergised circuit of a double-circuit transmission line when the other circuit is already commissioned.

The difficulties encountered due to extreme proximity of the power and telephone conductors are as follows:

(*i*) Severe induced voltages on the telephone circuit under fault conditions in power lines increasing with the length of the parallelism.
(*ii*) Excessive noise voltages induced magnetically under normal operating conditions.
(*iii*) High electrostatic voltages induced on telephone lines under normal operating conditions.

The induced voltages under the worst fault conditions will evidently rise above all prescribed safe limits. Normally, however, the electrostatic voltage induced under normal operating condition in these cases is so high, that an adequate protection for the latter will also take care of the voltages induced under normal conditions.

Noise voltage induced under normal condition will will also be sufficiently high to seriously affect the telephone communication so much so that speech is hardly intelligible. A device recently developed to partially eliminate noise voltages should be appreciably effective in such cases. Sometimes referred to as "Compandor", this device is essentially an amplifier-cum-attenuator unit.

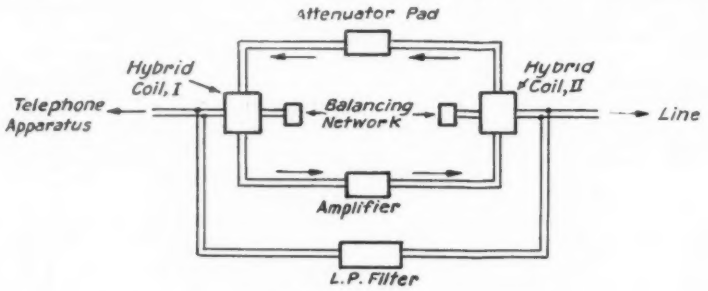

Fig. 1

The principle of operation of this device is briefly explained in the schematic diagram (Fig. 1). The diagram shows the unit as used at one terminal and a similar unit is to be connected at the other end.

The hybrid coil I and its balancing network are so connected that outgoing speech current from the apparatus will pass through the amplifier, i.e. it will

be amplified before being transmitted over the line. On the other hand, the hybrid coil II and its balancing network are so connected that the incoming speech current will pass through the attenuator pad and will be attenuated before being received by the telephone receiver. This arrangement effects a considerable improvement in signal-to-noise ratio. The unit is by-passed by a low-pass filter to allow ringing currents to pass through. Thus in the above arrangement the signal level is raised at the transmitting end before noise is picked up on the line in course of propagation of speech current. And since on the receiving end both the signal and the noise undergo attenuation to the same extent, the effective signal-to-noise ratio at the receiving end becomes higher with this device than without it.

In this case of employing unenergised power conductors for telephone purposes the electrostatically induced voltage presents a really serious problem. Due to the capacitances between the conductors and between the conductors and the ground, or in other words, due to the physical location of the telephone conductors in the electrostatic field produced by the power conductors, large potential to ground develops on the telephone conductors.

The following computations for electrostatically induced voltage apply to a typical example of telephone line running parallel and close to a 3 phase power line. (Fig. 2).

Let 1, 2, 3 represent the power conductors, 4 & 5 the telephone conductors and 1′, 2′, 3′, 4′ & 5′ the respective ground images of these conductors.

Let V_1, V_2 etc. represent the potentials in volts on the conductors and q_1, q_2, etc. charges in micro-coulombs/Km in the conductors.

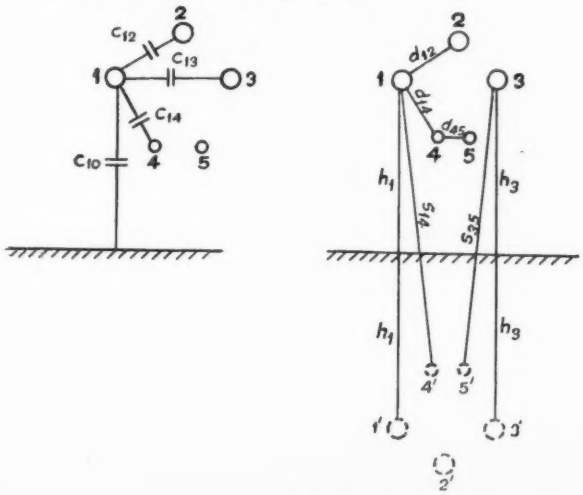

Fig. 2

Let C_{12}, C_{13}, C_{10} etc. represent capacitances in μF between various conductors and between conductors and earth as shown in the sketch.

Also let h_1, h_2, etc. represent height of the conductors above ground, r_1, r_2 etc. their radii, d_{14}, d_{12} etc. various distances between the conductors and S_{xy} the dist. of conductor x from the ground image of conductor y.

Now, charge on conductor 1 will be given by

$$q_1 = C_{10}\ V_1 + C_{12}\ (V_1 - V_2) + C_{13}(V_1 - V_3) + C_{14}(V_1 - V_4) + C_{15}(V_1 - V_5) \quad \ldots\ldots\ldots\ldots (1)$$

Charges on the other conductors, viz. q_2, q_3 etc. can be similarly evaluated. Since formulae for capacitances are cumbersome, a system of equations using symbols to represent reciprocals of capacitances is given below:

$$\left.\begin{aligned} V_1 &= K_{11}q_1 + K_{12}q_2 + K_{13}q_3 + K_{14}q_4 + K_{15}q_5 \\ V_2 &= K_{12}q_1 + K_{22}q_2 + K_{23}q_3 + K_{24}q_4 + K_{25}q_5 \\ V_3 &= K_{13}q_1 + K_{23}q_2 + K_{33}q_3 + K_{34}q_4 + K_{35}q_5 \\ V_4 &= K_{14}q_1 + K_{24}q_2 + K_{34}q_3 + K_{44}q_4 + K_{45}q_5 \\ V_5 &= K_{15}q_1 + K_{25}q_2 + K_{35}q_3 + K_{45}q_4 + K_{55}q_5 \end{aligned}\right\} \ldots\ldots (2)$$

where K's are constants, their respective magnitudes being determined as per a typical example given below.

When the lengths of the conductors are large in relation to the distances between them and to their heights above grounds and when these distances are in turn large in relation to the wire radii, the constants may be expressed as follows:

$$\left.\begin{aligned} K_{nn} &= 18 \log_e \frac{2h_n}{r_n}\ \text{Km}/\mu\text{F}\ (n = 1, 2, 3 \text{ etc.}) \\ K_{xy} &= 18 \log_e \frac{S_{xy}}{d_{xy}}\ \text{Km}/\mu\text{F}\ (x \neq y) \end{aligned}\right\} \ldots (3)$$

where r, h, d, s have significances mentioned before.

As the charges on telephone conductors are negligible for all practical purposes, we put $q_4 = q_5 = 0$ and hence the system of equations reduces to

$$\left.\begin{aligned} V_1 &= K_{11}q_1 + K_{12}q_2 + K_{13}q_3 \\ V_2 &= K_{12}q_1 + K_{22}q_2 + K_{23}q_3 \\ V_3 &= K_{13}q_1 + K_{23}q_2 + K_{33}q_3 \\ V_4 &= K_{14}q_1 + K_{24}q_2 + K_{34}q_3 \\ V_5 &= K_{15}q_1 + K_{25}q_2 + K_{35}q_3 \end{aligned}\right\} \ldots\ldots\ldots (4)$$

From the first three equations in (4), we get

$$q_1 = \frac{1}{\Delta}\begin{vmatrix} V_1 & K_{12} & K_{13} \\ V_2 & K_{22} & K_{23} \\ V_3 & K_{23} & K_{33} \end{vmatrix},\quad q_2 = \frac{1}{\Delta}\begin{vmatrix} K_{11} & V_1 & K_{13} \\ K_{12} & V_2 & K_{23} \\ K_{13} & V_3 & K_{33} \end{vmatrix},\quad q_3 = \frac{1}{\Delta}\begin{vmatrix} K_{11} & K_{12} & V_1 \\ K_{12} & K_{22} & V_2 \\ K_{13} & K_{23} & V_3 \end{vmatrix}$$

where $\Delta = \begin{vmatrix} K_{11} & K_{12} & K_{13} \\ K_{12} & K_{22} & K_{23} \\ K_{13} & K_{23} & K_{33} \end{vmatrix}$

Since V_1 V_2, V_3 are the known voltages on power conductors, viz. $V_1 = V_{max} \sin(wt + \alpha)$, $V_2 = V_{max} \sin\left(wt + \alpha - \frac{2\pi}{3}\right)$ and $V_3 = V_{max} \sin\left(wt + \alpha - \frac{4\pi}{3}\right)$, values of q_1, q_2 and q_3 can be found.

Substituting these values in the last two equations of system(4) instantaneous values of V_4 & V_5, the electrostatically induced voltages on telephone conductors, can be found in the form:—

$$V_4=v_1\sin(wt+\alpha)+v_2\sin\left(wt+\alpha-\frac{2\pi}{3}\right)+v_3\sin\left(wt+\alpha-\frac{4\pi}{3}\right),\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

and a similar expression for V_5.

From the above equation (5), the effective value of V_4 can be found from the formula,

$$|V_4|=\frac{1}{\sqrt{2}}\sqrt{v_1^2+v_2^2+v_3^2-v_1v_2-v_2v_3-v_3v_1},\ldots(6)$$

Similarly $|V_5|$ can be found.

Applying the above formulae to a typical example of employing power conductors for telephone purposes discussed earlier, we get the following induced voltages which are very approximate:—

The constants in this case can be found from the physical configuration of the conductors on the 132 kV transmission line tower, with one of the circuits energised at 66 kV (fig. 3)

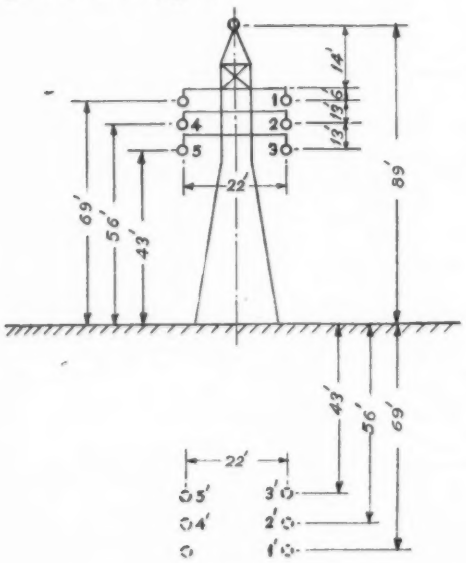

Fig. 3

Overall diameter of the ACSR conductors used being 0·806″, $r_1=r_2=r_3=0·034$ ft.
Expressing all the distances in feet,

$h_1=69$, $h_2=56$, $h_3=43$;

$d_{12}=13$, $d_{15}=34$, $d_{25}=25·5$,
$d_{13}=26$, $d_{23}=13$, $d_{34}=25·5$,
$d_{14}=25·5$, $d_{24}=22$, $d_{35}=22$;

$S_{12}=125$, $S_{15}=114$, $S_{25}=101·4$,
$S_{13}=112$, $S_{23}=99$, $S_{34}=101·4$,
$S_{14}=127$, $S_{24}=111·4$, $S_{35}=88·8$.

Computing according to equation (3), we get

$K_{11}=150$, $K_{12}=40·8$, $K_{23}=36·6$, $K_{34}=24·9$,
$K_{22}=146$, $K_{13}=26·3$, $K_{24}=29.6$, $K_{35}=25·1$,
$K_{33}=141$, $K_{14}=28·9$, $K_{25}=24·9$,
$K_{15}=21·8$,

Hence the first three equations of the system (4) give

$$\left.\begin{aligned}150q_1+40·8q_2+26·3q_3&=V_1\\40·8q_1+146q_2+36·6q_3&=V_2\\26·3q_1+36·6q_2+141q_3&=V_3\end{aligned}\right\}\ldots.(7)$$

Solving,

$$\left.\begin{aligned}q_1&=10^{-2}(0·731V_1-0·18V_2-0·086V_3)\\q_2&=10^{-2}(-0·182V_1+0·778V_2-0·168V_3)\\q_3&=10^{-2}(-0·089V_1-0·168V_2+0·077V_3)\end{aligned}\right\}..(8)$$

From $V_4=K_{14}q_1+K_{24}q_2+K_{34}q_3$,

we get $V_4=10^{-2}(13·59V_1+13·61V_2+11·75V_3)$.

Putting $V_1=V_{max}\sin(wt+\alpha)$, $V_2=V_{max}\sin\left(wt+\alpha-\frac{2\pi}{3}\right)$, $V_3=V_{max}\sin\left(wt+\alpha-\frac{4\pi}{3}\right)$, and $V_{max}=66\sqrt{2}$ kV,

we have $V_4=66\sqrt{2}\times10^{-2}\left[13·59\sin(wt+\alpha)+13·61\sin\left(wt+\alpha-\frac{2\pi}{3}\right)+11·75\sin\left(wt+\alpha-\frac{4\pi}{3}\right)\right]$

Hence $|V_4|=66\sqrt{2}\times10^{-2}\frac{1}{\sqrt{2}}\sqrt{(13·59^2+13·61^2+11·75^2-13·59\times13·61-13·61\times11·75-11·75\times13·59)}$

$=0·66\times\sqrt{3·39}$

$=1·21$ kV.

Similarly, $V_5=K_{15}q_1+K_{25}q_2+K_{35}q_3$

$=10^{-2}(9·22V_1+11·37V_2+13·23V_3)$

and $|V_5|=66\sqrt{2}\times10^{-2}\times\frac{1}{\sqrt{2}}\sqrt{(9·22^2+11·37^2+13·23^2-9·22\times11·37-11·37\times13·23-13·23\times9·22)}$

$=0·66\times\sqrt{12·12}$

$=2·3$kV.

Although these are very approximate calculations, the order of the voltages induced are between 1 and 2.5 kV. Due to presence of thick vegetation in the neighbourhood, rail tracks or metallic conductors, the induced voltages are likely to be reduced. Also by earthing the third conductor on the unenergised circuit and on account of close proximity of the overhead groundwire and large metallic body of the tower as well as transposition of the conductors, considerable reduction in the induced voltages is anticipated.

(*Continued on page* 84)

Editorial

The Basic Issue

The Damodar Valley Corporation is making steady progress. The Bokaro Power Station, the largest thermal plant in Asia, and the Tilaiya Dam and Power house are already in operation. The Konar Dam is complete. The Durgapur Barrage is being opened. The Maithon and the Panchet Hill Dams are fast nearing completion. The erection of Transmission Lines and Substations has progressed considerably. The first phase of the Damodar Project is thus rapidly coming to a close. And the demand for power in this richest mineral bowl of the country has been increasing at such a fast pace that already the items of the second phase are being considered for immediate execution. The major problem of soil conservation now looms larger on the horizon than ever before and awaits to be tackled in a bold and big way. The DVC can now well look back upon a creditable performance with a sense of self-confidence. But a larger programme awaits it. We are sure that with the confidence born of experiences the DVC will face its new tasks courageoulsy.

But in contrast to all this, Sri P.P. Varma's contribution appearing in this issue makes depressing reading. He is the only continuing member in the DVC, the other two being new members and belong to the Indian Civil Service. As such his views deserve special attention. The DVC was launched with great acclaim amidst popular enthusiasm in 1948 i.e. soon after India's independence, and it was hoped that it will take the same place in the mind of the people of Asia as the TVA occupies in America today. But Sri Varma's reflective thoughts seem to cast some shadows. This is a matter of serious public concern. For DVC as an institution is not a local issue; it obtains an all-India significance in the sense that upon its success or failure would depend the future framework of administration of the country's river valley projects. All the other major projects are at present being run on an *ad-hoc* basis and merely as an engineering constructional organisation.

It will be remembered that not long ago a committee called the "DVC Enquiry Committee" was appointed with Sri P. S. Rau, the present Chairman of the DVC, as Chairman, and it submitted its report covering the question of "Adequacy of the DVC Act." It came to the conclusion "that on an overall view of all the circumstances the semi-autonomous corporation is the best method yet devised, of executing multi-purpose projects efficiently and economically. Where it has failed to achieve results, it is more because of the defects in the personnel of the Corporation or of Government departments or of both than anything inherent in the Corporation concept itself" (P. 75). The general public as well as the Government of India and of the States concerned did not appear to disagree with this view and it was a relief to know that the DVC experiment would be given a fair trial. Why then this strain of pessimism in Mr. Varma so soon after the publication of the Report? It is time that we try to understand the basic issues involved in this significant experiment.

As far as we could understand, after carefully going through all the literature on the subject available to the public, it appears to us that the *basic and fundamental defect of the DVC structure is that it is an inter-State agency and not a purely Central agency*. We had pointed out this defect in our Memorandum to the DVC Enquiry Committee. But unfortunately this point of view was not even considered by the Committee, probably because its terms of reference did not permit it to go behind the basic assumptions of the DVC Act. But if the DVC is expected to function on TVA principles and to produce similar results in the region, this crucial structural problem has to the faced, early or late.

The DVC, as it now stands and the way it is shaping, is tending in a direction farther from the TVA. Let us be clear about it, and it would be a franker attitude to say clearly that the TVA approach does not suit our country rather than talk about the DVC as an Asian version of the TVA and simultaneously give a *coup de grace* to the basic TVA concepts which inspired the DVC.

According to Mr. Varma, "the present policy as laid down by a Conference of Participating Governments in July last is that the responsibility of the DVC should be confined to development activities directly connected with the maintenance of reservoirs and canals and a few small scale industries after they have been approved by the Government". The DVC has thus been "discouraged to undertake development works". This is clearly contrary to the DVC Act, Section 12, which includes among its functions "the promotion of afforestation and control of soil erosion in the Damodar Valley, and the promotion of public health and *agricultural, industrial, economic and general wellbeing* in the Damodar Valley and its area of operation."

Thus the responsibility entrusted to the DVC by the Parliament and the two State Legislatures of Bengal & Bihar under the Act for the development of the Valley is taken away from it by an "Inter-State Conference of Participating Governments." The first obvious question is: Is this a proper procedure to do so?

Secondly, after this decision, what remains of the DVC ? It should now be conceived as an engineering organisation for purposes of construction of engineering structures and of their maintenance, and as wholesale distributors of electrical power and irrigation waters. Conceived on these lines, it can well be an Inter-State agency of operation with its limited and specific technical and commereial functions. There is no question of policy-making in regional developmental activity or of leadership and guidance by it in these matters; these can be, as now are, determined by the Inter-State Conferences. If that be so desired, then the whole paraphernalia of a DVC Act may not be necessary.

Thirdly, it appears that on all important matters of policy which the DVC should decide for itself, it is

the Inter-State Conference that decides and the DVC is left with only the duty to execute them. Yet the DVC is known as a "policy-making body". If this be the essence of the situation, and is intended to be continued as right and proper, then let us cease to think of DVC as an "automomous" or "semi-autonmous" institution.

The DVC Enquiry Committee strongly criticised the operation of the Advisory Committee (and its technical committee) on the grounds that it was becoming a "Controlling Committee". The Inter-State Conference is more so and the DVC, as a consequence, seems to be losing the sense of leadership and guidance in the region and is accepting the status of an executive with three masters to please simultaneously.

As long as the DVC will be enveloped in an atmosphere of a three-cornered proprietory partnership, it will never be able to come into its historic self and perform the true function expected of it in the region.

Sometime back Mr. P. H. Appleby submitted a report on Public Administration in India. He "brought to his enquiry a freshness of outlook and experience and insight into social and governmental problems which lend special weight to his observations and suggestions". He rightly points out that the "Centre" is all "staff", with no administrative "line", and that the system of administration in India is characterised by "excessive coordination before the fact of action, slowing and retarding action". With regard to power and irrigation projects, he says, "What is being done is slowed also by cumbersome and multiple reviews". "A special law and structure mildly mitigate the problem for the D.V.C., as a partial offset to the burden of three governmental reviews. I do not believe that it should be any more "autonomous" than it is. (The TVA in the United States goes too far in that direction.) But the procedures of governmental control are archaic and unduly confining. Such undertakings should be exclusively carried on by the Centre, without control being shared with states". While one need not accept all his recommendations, it needs stressing that his major emphasis on the structural weakness in the administration in India deserves careful study.

If a regional agency is to be effective in its resource development task, it would be a far better device to have it purely as a Centre's Agency in the region cooperating with the States concerned *on an equal footing*. In that case the idea of "Inter-State Conference", as it now exists, would not arise. The DVC will determine its own policy within a guiding framework provided by the Centre. And the DVC, as the Centre's agent, will enter into consultative and cooperative relationship with the States, either singly or jointly, as merits of particular issues may demand.

As we have explained in our Memorandum to the DVC Enquiry Committee, such a structure of the DVC would not be a threat to the State's authority or to its people in anyway, as long as it accepts basic TVA principle, namely, "A policy fixed by law that the regional agency work cooperatively with and through local and State agencies." Rather, the function of the DVC so conceived would be more in the nature of a *catalytic agent* in promoting development activities such as in the field of agriculture, soil conservation practices, afforestation, small-scale industries, rural electrification, education, public health, research, etc. This is the TVA way and has been tested in region which is much more State-conscious than most regions in India are. There is one more aspect that needs to be stressed. River Valley Development is not a mere engineering concept, though that is its kernel. Today it is dominated by the "engineering approach" and administratively channelled through the "Irrigation and Power" Ministerial canals. But it would be a great mistake if this myopic perspective persists. River Valley Development must be conceived as a "*regional resource development*" *approach* including the human resources. Water is not the only resource of the region; land, minerals and man are also important resources in a region.

It seems to us that there is some persistent confusion of issues with regard to the task of river valley development. The best course to help matters is to boldly raise the basic issues and discuss them squarely in public and come to a judgement with a background of a clearer comprehension of the problem of regional resource development as whole.

(*Continued from page* 63)

Mechanised Earth moving for Development

from Headquarters. Regular and work-charged staff's allowances are also included in operational cost, under this head. Fuel as actually consumed by machines is kept in detail in Log Sheets and included in the Direct Charges.

Conclusion

The work involved in the Circle varied considerably from job to job involving a total of 93,00,000 cubic yards of earth movement and 1600 acres of clearance of jungle. Although the establishment of this Circle was originally for a limited purpose, the utility of the Circle has been found for all kinds of miscellaneous works for the various projects of the Corporation as well as outside agencies. The experience gained by the various teams of the Circle has been tremendous and considerable operational and maintenance staff as well as officers for supervision in the field have been trained to work as a team at a continually high level of efficiency. Large number of local boys have also been trained. From time to time, we are called upon without notice to undertake works of importance and urgency, and our staff have been doing these without difficulty. The success of the Circle is due entirely to the Officers, Foremen, Operators, Mechanic Greasers and othere technical and non-technical staff, who have played their part well.

Transmission of Electricity

At the present stage in the development of India, the Central Government and the various State Governments are most actively engaged in the execution of the various multi-purpose projects and power projects throughout the country.

With the initiation of the First Five-Year Plan, enormous sums of money were made available for electrical development through the construction of the multi-purpose and, separately, the solely power projects, all of which have been given priority along with irrigation projects. Under the First-Five-Year Plan, a sum of over Rs. 700 crores was allocated for irrigation and power projects and, in the light of experience, various adjustments have since been made to that figure.

During the years preceding 1951, there had been considerable activity all over India in connection with irrigation and power projects. Many schemes of varying size had been taken up for construction and in the First Five-Year Plan every effort was made to integrate such schemes and to bring them to fruition. Where the schemes had already been planned to meet only the immediate requirements of the locality, new and more extensive schemes were initiated. It was hoped that when such schemes were completed, there would be an increase of power to the extent of 1.1 million kilowatts. In addition to the projects included for execution under the First Five-Year Plan, there were many other potential irrigation and power projects under consideration, which were brought forward for closer investigation.

In preparing the First Five-Year Plan, it was realized that it was only by utilizing available water resources for irrigation purposes and for the generation of power coupled with the adoption of extensive measures for improving the standards of agricultural practice and the promotion of cottage, small scale and large scale industries, with the help of cheap electric power, that an appreciable rise in the standard of living of the people could be achieved.

The Second Five-Year Plan which is now being finalised will undoubtedly provide for extensive additional developments in connection with irrigation and power projects and it is said that the gross expenditure in this connection is likely to exceed Rs. 1,000 crores.

The figures mentioned above cover the entire expenditure on power schemes incorporating not only dams, hydro-electric power houses and thermal power stations but also the main electricity transmission lines for the distribution of electricity to potential consumers.

In every scheme for the provision of electrical power there are two major factors to be considered: firstly, the generation of electricity, either by hydro-electric or thermal power stations, and secondly, the transmission and distribution to consumers of the electricity so generated. The various schemes which have already been completed, which are under execution and which are planned for the future, are designed for the transmission of power to the areas round about the generating stations, where, in many cases, fresh industries are being developed, and, also for bulk transmission of electricity to supply remote areas and link up with adjacent electrical networks.

The methods of distribution vary according to the quantity of available power and the sources of consumption. Taking for example, the largest multi-purpose projects, the major tranmission lines will operate ultimately at 220,000 volts, 132,000 volts, 110,000 volts and 66,000 volts. The use of the highest voltages enables very much larger blocks of power to be transmitted for greater distances than would be possible on lower voltages lines. It will thus be seen that any single power project in its final stages of development provides a complete network throughout the area concerned. As already mentioned, large blocks of power can be transmitted at the highest voltages and the changes to lower voltages take place at substations equipped with transformers and other complicated switchgear. From 66,000 volts the next step down would be normally to 33,000 volts or 11,000 volts, again through suitable substations. In some instances, large installations, such as the Sindri Fertilizer Factory or large Steelworks, take their own power supply in bulk at a high voltage but for smaller concerns and lesser industrial units, the power supply is usually taken at 11,000 volts, 6,600 volts or 3,300 volts.

Below this state, we come to the general low tension distribution network radiating from 11,000 volt, 6,600 volt or 3,300 volt substations, transmission at 400/230 volts being effected to small factories and workshops and for housing, street lighting and general utility purposes.

The common factor amongst all the overhead transmission lines is the conductor, which is made of various metals and of different sizes to suit the mechanical and electrical conditions prevailing in each particular instance. Generally speaking, the conductors which are used for overhead transmission lines are of the following types:

(a) *Steel Cored Aluminium Conductors*

This conductor, as its name applies, consists of a core of High Tensile Steel wire rope, around which is laid a number of aluminium wires. This type of conductor, at the present time, is used invariably for the extra high voltage transmission lines where the mechanical strength which is provided by the steel core is absolutely essential in order that long spans

can be erected with the minimum of sag. Generally speaking, the large transmission lines of 66,000 volts, 132,000 volts and 220,000 volts are erected on steel lattice-work towers which are installed at intervals varying from 1,000 to 1,500 ft. Steel Cored Aluminium Conductor is also used for long river-crossings which have to be negotiated, some of which are often as much as 4,000 ft. and, in such instances, the supporting towers on the banks of the rivers are as high as 300 ft. or perhaps more. This great height is necessary in order to allow for the heavy sag of the conductors and at the same time to provide the necessary clearance which may be required for shipping. Steel Cored Aluminium Conductors are also used for the lower voltage transmission lines where the strength of the conductor enables longer spans to be used than would be the case with other types of conductor.

(b) *Plain Aluminium Conductors*

As its name applies, these conductors consist of a strand of solid aluminium wire without a steel core. Naturally, the mechanical strength of these conductors is less than that of Steel Cored Aluminium Conductor and, consequently, the spans on which the conductor can economically be installed, are less. On the other hand, the price of the conductor is cheaper and consequently, it is used normally for the lower voltage lines where the sizes of conductors required are fairly small owing to electrical considerations. It is also used on low tension distribution lines where the spans are limited by having to run through streets and across populated areas.

(c) *Bare Copper Conductors*

These conductors are either stranded or solid and are made from high conductivity bare electrolytic copper. Only a few years ago, this type of conductor was used invariably on low tension and also for the lower voltage transmission lines upto about 33 KV. Before that time and prior to the development of Steel Cored Aluminium Conductor, Copper Conductors were naturally used for all transmission lines. They are at present the most commonly used conductors for the lower high voltage and for low tension distribution lines. Bare Copper Conductor has a mechanical strength greater than that of Plain Aluminium Conductor and, consequently, can can be installed with less sag and longer spans. Its price has been fluctuating considerably during the last few months on account of rapid changes in the price of Copper Wire Bars.

(d) *Cadmium Copper Conductors*

This conductor has a mechanical strength greatly in excess of Bare Copper Conductor, but with slightly less electrical conductivity owing to the introduction of a small percentage of cadmium. Owing to its high price, it is not used to a very large extent for general tranmission line work and its use is limited in practice to special crossings and special long spans where the reduction of sag is of importance.

As a matter of interest, Cadmium Copper is most satisfactory for use as the conductors for railway electrification and for trolleybus and tramway routes. In these cases, the cadmium copper contract wire is solid and of grooved construction, the grooves being utilised for attaching the supports which carry the contact wire above the rails or trolleybus routes and an even running surface is provided for the current collecting pantograph of the railway locomotive or for the current collecting trolley arm fitting for the tramcars and trolleybuses. In these instances, the cadmium copper trolley wire is recommended on account of its being much harder than bare copper so that the contact surface does not wear away so quickly. Factory manufacture and production of Cadmium Copper Wires is, however, complicated and fraught with difficulties which are not generally known to producers inexperienced in its production.

(e) *Special Conductors*

From time to time special conductors are utilized for different purposes, these being produced from a mixture of different wires, such as, for example, steel cored copper stranded wire, copper cored steel stranded wire, hollow stranded aluminium or copper conductors, and from time to time various alloys have been introduced to try to improve the mechanical strength of existing materials. While the use of such special conductors can be justified in certain cases, their higher prices will not be economical, generally speaking for use on a large scale. In the case of wires such as steel cored copper, there is serious danger of chemical action between the different metals and these conductors are now rarely used.

(f) *Copperweld Conductors*

This is a patented copper covered steel wire, made with a steel core surrounded by an electric welded covering of pure copper. Copperweld is mostly used for all types of communication lines from the most important grades of construction, where safety and reliability are the main requisites, to the lightest types of lines where lowest initial cost is essential. It is used for multi-channel carrier telephone and carrier telegraph lines, toll lines, important exchange lines, rural lines, forestry lines, telephone circuits in conjunction with transmission lines, and is eminently suitable for special long span construction because the tensile strength of copperweld wire is 2 to 2½ times the strength of hard drawn copper and greater in strength than any other type of overhead wire having comparable electrical properties.

Underground Cables

The notes on Conductors given above naturally apply to those which are used for overhead transmission lines. In every power project it is also necessary to utilize insulated cables which are placed underground, these being used in positions where overhead transmission is not practicable for various reasons, where housing and other obstructions prevent

(*Continued on page* 83)

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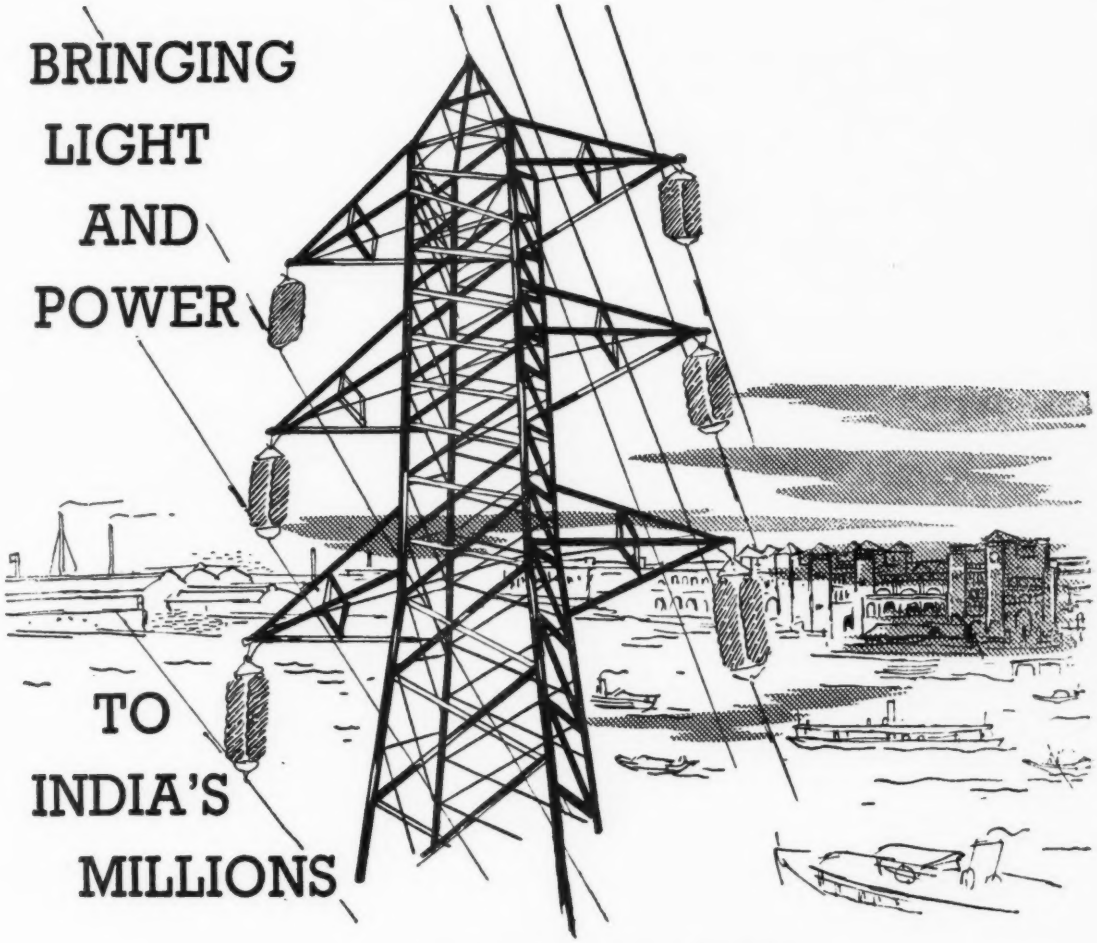

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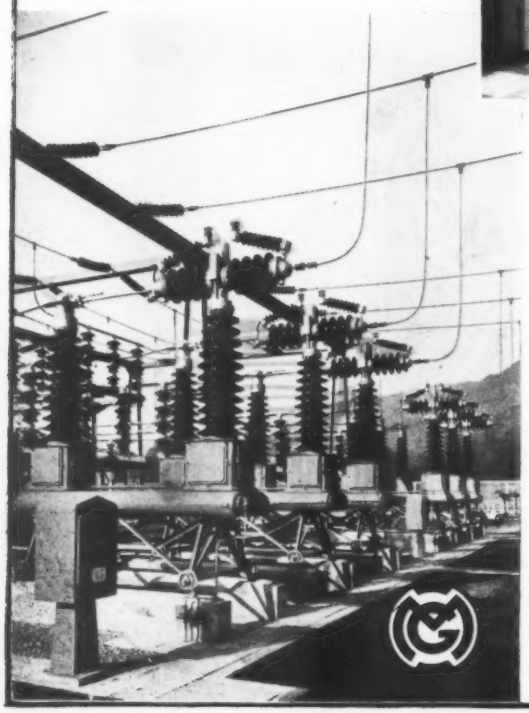

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Among the most outstanding manufacturers of heavy electrical equipment in Europe today is Le Material Electricque S-W, Paris. Popularly known as S-W, this company has supplied various types of heavy electrical plant and machinery to countries all over the world, earning a high reputation everywhere for dependability.

S-W owns three factories. The main one is in Champagne-Sur-Seine, only 40 miles from Paris and is manufacturing heavy electrical equipment for over 50 years now. The second factory is located at Lyon where large power transformers and motors are manufactured. The third factory is at Puteaux where all kinds of pumps, special switchgear, heavy service of metallurgical and hoist work and apparatus for the industrial application of electronics are made.

Among the numerous items of S-W's manufacture are:

Large power transformers (Shell and Core type)
A.C. Generators for Hydro and Steam Power Plants
Synchronous Condensers
A.C.—D.C. motors of all types
Large pumping sets
Industrial application of Electronics: Ignitron Rectifiers, Precipitron Air Filters, Control and Regulation
Metallurgical and Mining equipment
Railway traction

Amongst the important works recently executed are:

1 turbo-alternator of 143,000 kVA at Arrighi in France.
2 A.C. hydro generators of 70,000 kVA at Genissiat in France.
2 sets of 100 mVA transformers at 220 kV in France.
25 transformers ranging from 3 to 30 mVA at 150 kV for Turkey

Electrical equipment of the D.C. locomotive BB 9004 which has just beaten the world speed record with 208 miles per hour.

43 A.C. traction locomotive at 25 kV equipped with IGNITRON rectifiers for French Railways.

MERLIN & GERIN

In the field of electrical engineering, Merlin & Gerin of Grenoble, Franche, have specialized in all kinds of switchgear, high tension circuit breaker—air blast and bulk oil, disconnecting switches, low tension circuit breakers, switchgear for power and substations —indoor and outdoor, mining and marine equipment. Sound and robust construction—inherent characteristics of Merlin & Gerin equipment—ensure long and reliable service even under the most arduous conditions.

Five factories of Merlin & Gerin are located around Grenoble in France.

Amongst the outstanding achievement of Merlin and Gerin, we can mention:

220 kV Air blast circuit breakers at the power laboratory of Fontenay in France

4 complete sub-stations in Belgian Congo

15 substations at 154 kV in Turkey

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In India both Schneider-Westinghouse and Merlin and Gerin are represented by Blue Star Engineering Co. (Bombay) Ltd., with main offices at Kasturi Buildings, Jamshedji Tata Road, Bombay 1, and branches at Calcutta, Delhi and Madras.

(*Continued from page* 80)

the use of overhead lines and also where the power supply runs into power stations, sub-stations and buildings. Although more expensive than overhead transmission, under-ground cables, particularly for lower voltage lines, are also run along streets in preference to overhead construction, especially where such streets are already well occupied with existing electricity transmission lines and telephone and telegraph lines.

There is an enormous variety of underground cables which differ according to the voltage to be transmitted and local conditions but, in general, they follow somewhat similar construction consisting of bare high conductivity copper strands, the insulation comprising paper or in some cases vulcanised rubber, these being laid up with interstices of suitable packing materials, the whole being surrounded by various layers of insulating material and finally finished with a lead sheath and hessian tape with protective coverings of either steel tape or steel wire armour which protects the cable from mechanical damage. Recent developments include a final sheath of aluminium instead of lead which offers considerable saving in weight.

Special cables have been developed for the high voltage of 110 KV, 132 KV and 220 KV, but these involve special technique and processes which are far beyond the scope of the present article.

Indigenous Manufacture

Indigenously every type of overhead conductor is now manufactured and most of the factories in

existence are gearing up for still higher and better production. In Tatanagar, at the Works of The Indian Cable Co. Ltd., overhead conductors, solid and stranded, for telephone and power tranmission, were first manufactured in 1923. Many difficulties had to be surmounted before the Works could achieve their present eminence as the largest manufacturer of rubber cables and overhead conductors in India.

A.C.S.R. (Aluminium Conductors Steel Reinforced) and All-Aluminium Conductors were first manufactured in the middle thirties. Copperweld and Cadmium were first manufactured round about the same time. A.C.S.R. and Aluminium have made enormous strides everywhere but Copperweld and Cadmium production are still in their infancy largely due to the present Fiscal Policy of the Government.

There are other factories in existence in Shamnagar, The National Insulated Cable Co. of India Ltd., a somewhat smaller unit than the Indian Cable Co. Ltd., but where the same high grade range of materials are manufactured today. Newcomers in the field of overhead line construction are Aluminium Industries Ltd., Kundra, and the Electrical Machines Corporation, Ltd., Calcutta. A further unit to come into production shortly is the Hindustan Cables Ltd., at Rupnarainpur.

India is well equipped in its indigenous industry for the manufacture of overhead conductors and rubber cables to make the dreams of the electrification of India in the First and Second Five-Year Plans come true, and the people can rest assured that these same industries are striving to bring light and power to every corner of India.

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Communication Facilities for Large Power Transmission Systems

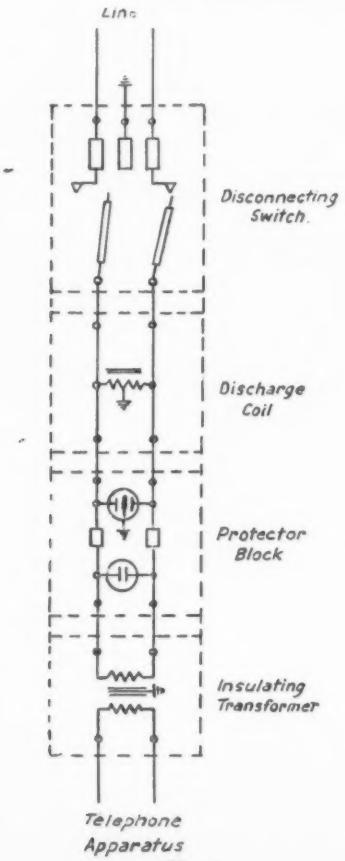


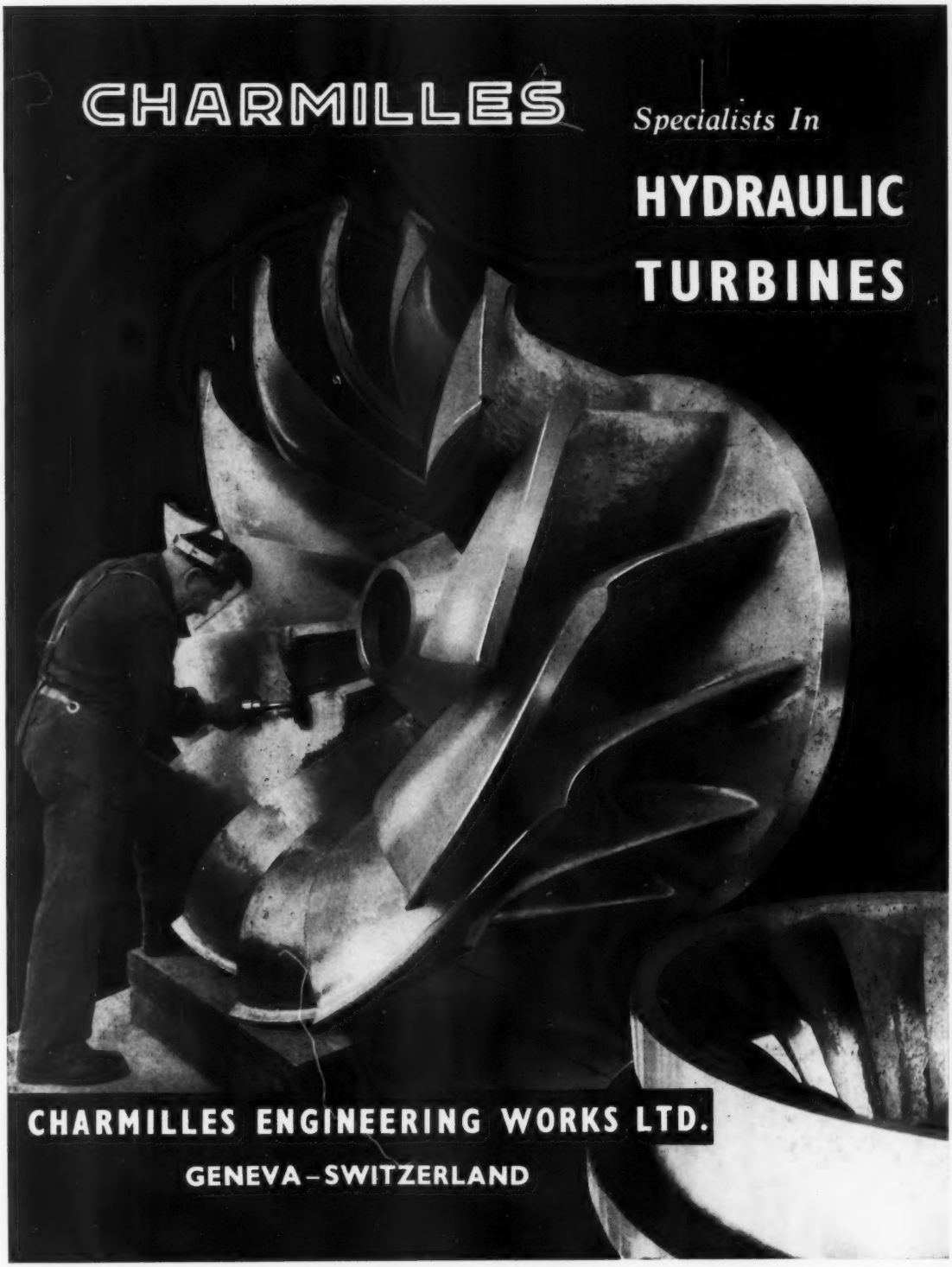
Fig. 4

In all cases where telephone lines are carried on the same pole which carry the power conductors, the telephone apparatus should be adequately protected by connecting High Tension Protection Equipment at both the terminals. Connected between the line and the apparatus, these usually consist of a disconnecting switch, a discharge coil, a protector block and an insulating transformer (Fig. 4).

With the disconnecting switch are provided HT fuses and an air gap arrester. Protector block includes fuses and a three-pole and a two-pole rare gas tubes which function as overvoltage arresters for operating voltages below those of air gap arrester. Discharge coils help in neutralising the unbalance noise-voltages induced in the two limbs of the telephone wires and thus provide a by-pass for this voltages to the telephone apparatus.

Insulating transformers are primarily used to insulate the telephone instrument from the line galvanically. It also serves as an impedance matching device and reduces the overall attenuation of the channel by avoiding reflection at the junction of unequal impedances.

This type of equipment is usually designed for indoor mounting. The H.T. Protection equipment available so far are normally designed to withstand induced voltage of the order of upto 1 kV and is usually recommended for use with telephone circuits strung below power lines with voltages upto 66 kV. This sets a limit to installation of H.T. protected telephone lines below power conductors carrying voltages upto a maximum of 66 kV.



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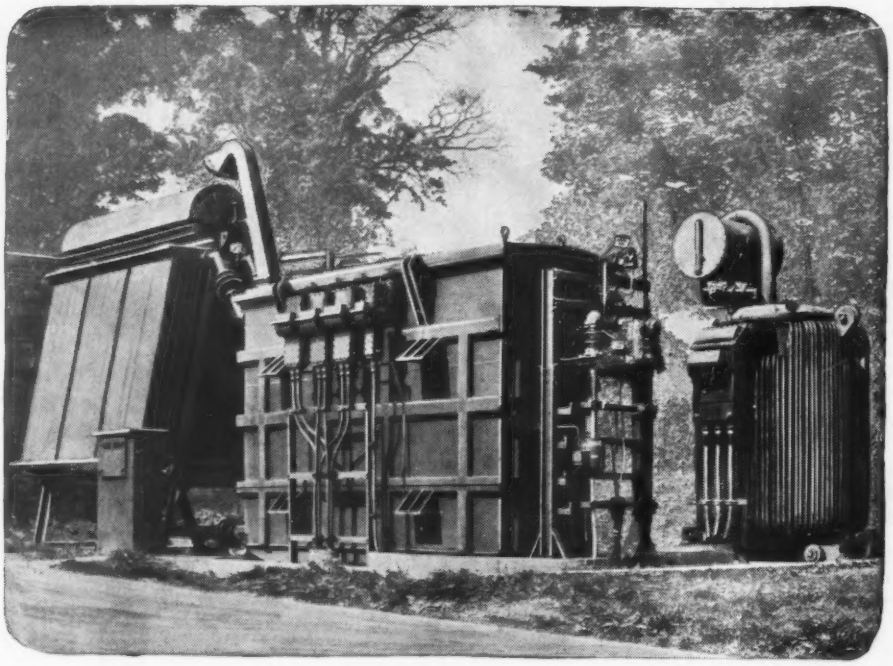

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